PB90-137324

Ecological Risk Assessment Methods: A Review and Evaluation of Past Practices in the Superfund and RCRA (Resource Conservation and Recovery Act) Programs (Executive Summary Included)

(U.S.) Environmental Protection Agency, Washington, DC

Jun 89

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO. EPA-230-03-89-044

2.

3. Recipient's Accession No. PB90-137324

4. Title and Subtitle Ecological Risk Assessment Methods: A Review and Evaluation of Past Practices in the Superfund and RCRA Programs

5. Report Date June 1989

6.

7. Author(s) Craig Zamuda

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
Office of Policy Analysis (PM-220)
U.S. Environmental Protection Agency
Washington, D.C. 20460

13. Type of Report & Period Covered

14.

15. Supplementary Notes
Includes an Executive Summary

16. Abstract (Limit: 200 words)

Substances released from sites subject to the Comprehensive Environmental Response, Compensation, and Liability Act and the Resource Conservation and Recovery Act have the potential to cause adverse effects to human health and the environment. Although there are numerous examples of adverse ecological impacts being caused by releases of hazardous substances and wastes, programs have focused primarily on identification, analysis, and mitigation of potential adverse effects to human health. As a consequence of this program emphasis, relatively little information is available concerning the overall extent of ecological impacts at sites. EPA/OPA initiated a study of the nature and extent of ecological impacts at CERCLA and RCRA sites re. the methods that have been or could be used to evaluate ecological impacts at these sites, and past ecological risk management decisions and issues at OSWER waste sites.

17. Document Analysis a. Descriptors
ecological impact
human health and environment

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement:
No restriction on distribution. Available from
NTIS, Springfield, VA 22161

19. Security Class (This Report) unclassified

20. Security Class (This Page) unclassified

21. No. of Pages

22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77)

United States
Environmental Protection
Agency

Office of Policy
Planning and Evaluation
(PM-220)

EPA-230-03-89-044
June 1989

PB90-137324

EPA

Ecological Risk Assesment Methods

A Review And Evaluation Of Past Practices In The Superfund And RCRA Programs

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

EPA-230-03-89-044

ECOLOGICAL RISK ASSESSMENT METHODS: A REVIEW AND EVALUATION OF PAST PRACTICES IN THE SUPERFUND AND RCRA PROGRAMS

Office of Policy Analysis
Office of Policy, Planning, and Evaluation
U.S. Environmental Protection Agency
Washington, DC

June 1989

ACKNOWLEDGMENTS

This document was developed by EPA's Office of Policy Analysis (OPA) within the Office of Policy, Planning and Evaluation. Dr. Craig Zamuda was the EPA project director, with support provided by Dr. Dexter Hinckley, Mr. Ron Benioff, and Mr. Mike Cox.

ICF Incorporated assisted EPA in development of this document. The ICF team was directed by Bob Hegner and included Margaret McVey, Simon Heart, Michael Troyer, Baxter Jones, and Randy Freed.

The authors of this document wish to acknowledge, with appreciation, the inputs, cooperation, and review provided by many other people who contributed to the project. This includes numerous individuals within the Department of the Interior (Fish and Wildlife Service and Office of Environmental Project Review), the National Oceanic and Atmospheric Administration, all ten EPA Regions, EPA Laboratores, EPA Headquarters, and several State organizations.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY v

1 INTRODUCTION 1

2 APPROACH TAKEN IN REVIEW OF METHODS 4

2.1 Review and Analysis of Site-Specific Methods 4

2.1.1 Review and Analysis of Methods used at CERCLA Sites 4

2.1.2 Review and Analysis of Methods used at RCRA Sites 5

2.2 Review and Analysis of Methods used in Regulatory and Policy Studies 5

2.3 Criteria Used to Evaluate Methods 6

3 SITE-SPECIFIC METHODS USED TO CHARACTERIZE ACTUAL IMPACTS AT OSWER SITES 7

3.1 Approaches Used to Characterize Actual Impacts 8

3.1.1 Evaluation of Biotic Community Structure 8

3.1.2 Analysis of the Morphological and/or Physiological Condition of Individual Organisms 15

3.1.3 Comparison of Environmental Concentrations of Contaminants to Ecological Benchmark Levels 18

3.2 General Evaluation of Approaches Used to Characterize Actual Impacts 18

4 SITE-SPECIFIC METHODS USED TO CHARACTERIZE POTENTIAL IMPACTS AT OSWER SITES 24

4.1 Approaches Used to Characterize Potential Impacts 24

4.1.1 Comparison of Environmental Concentrations of Contaminants to Ecological Benchmark Levels (Quotient Method) 25

4.1.2 Qualitative Evaluation of Potential Impacts from Estimates of Exposure Potential 31

4.1.3 Evaluation of Potential Impacts from Estimates of Hazard Potential 32

4.1.4 Quantitative Modeling of Adverse Effects to Ecosystems 36

TABLE OF CONTENTS (continued)

Page

4.2 General Evaluation of Approaches Used to Characterize Potential Impacts 36

5 METHODS USED IN REGULATORY AND POLICY STUDIES TO CHARACTERIZE ECOLOGICAL IMPACTS AT OSWER SITES 43

5.1 Screening-Level Analyses for Establishing Policy and Regulatory Priorities 43

5.1.1 Proximity of Waste Sites to Sensitive Environments 45

5.1.2 Survey of Damage Case Studies 45

5.1.3 Quantitative Modeling of Potential Impacts based on Damage Case Scenarios 47

5.1.4 Comparative Risk Estimation 48

5.2 Specific Methods for Evaluating Potential Ecological Impacts 49

5.2.1 Hazard Index for Multiple Contaminants 50

5.2.2 Ecosystem Exposure-Response Model 51

5.3 General Evaluation of Methods Used in Regulatory and Policy Studies 51

6 OPPORTUNITIES FOR ADDITIONAL METHODS DEVELOPMENT 56

6.1 Characterizing Exposure 57

6.1.1 Standardizing Exposure and Intake Assumptions 57

6.2 Characterizing Hazard 57

6.2.1 Characterizing Hazards from Single and Multiple Contaminants 57

6.2.2 Guidance in Using Media Toxicity Tests 57

6.2.3 Data Needs 58

6.3 Characterizing Exposure-Response 58

6.3.1 Derivation of Ecological Benchmarks 58

6.3.2 Wider Use of Existing Techniques and Approaches 59

TABLE OF CONTENTS (continued)

Page

6.3.3 Exposure-Response Data 59

6.4 Characterizing Risk 59

6.4.1 Receptor Characterization 59

6.4.2 Determining Areal Extent and Reversibility of Impacts ... 60

6.4.3 Determining the Ecological Significance of Impacts 60

6.4.4 Quantitative Ecological Risk Assessment Methodology 61

7 GENERAL IMPLICATIONS FOR OSWER AND SPECIFIC METHODS DEVELOPMENT OPPORTUNITIES FOR SELECTED OSWER PROGRAMS AND ACTIVITIES 62

7.1 General Implications for OSWER 62

7.2 Methods Development Opportunities for Selected OSWER Programs and Activities 63

7.2.1 Relationship to General Objectives of Ecological Assessment Methods 64

7.2.2 Opportunities for Methods Development in the RCRA Program 64

7.2.2.1 Regulatory Development 64

7.2.2.2 Hazardous Waste Definition and Determination ... 69

7.2.2.3 Subtitle C Permitting 70

7.2.2.4 Subparts F and S Corrective Action 72

7.2.3 Opportunities for Methods Development in CERCLA Programs and Activities 74

7.2.3.1 Removal Program 74

7.2.3.2 Pre-Remedial Activities 74

7.2.3.3 Selection of Remedy 76

7.2.3.4 Implementation and Completion of Remedy 77

8 LITERATURE CITED 79

TABLE OF CONTENTS (continued)

Page

APPENDICES

EXHIBIT A-1: LIST OF CERCLA SITES REVIEWED (ALPHABETIZED BY REGION) ... i

EXHIBIT A-2: LOCATION (EPA REGION) OF CERCLA SITES AND RCRA FACILITIES REVIEWED ... ii

APPENDIX A: SUMMARY OF SITE-SPECIFIC METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS ... A-1

APPENDIX B: SUMMARY OF SITE-SPECIFIC METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS ... B-1

APPENDIX C: SITE-BY-SITE LISTING OF METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS ... C-1

APPENDIX D: SITE-BY-SITE LISTING OF METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS ... D-1

APPENDIX E: GLOSSARY OF ENTRIES IN APPENDICES ... E-1

EXECUTIVE SUMMARY

This report includes a summary and analysis of methods used to characterize ecological impacts in policy and regulatory studies and at specific CERCLA and RCRA waste sites. In this report, the term "ecological assessment" is defined broadly to include any characterization or evaluation of exposure, hazard, risk, or injury to an ecological receptor. The purposes of this report are to:

- identify and summarize the methodological approaches used to characterize both actual and potential ecological impacts at CERCLA and RCRA waste sites,
- identify the ecological assumptions inherent in these approaches and the types of information they can and cannot provide,
- identify opportunities for additional methods development that would make current approaches for characterizing ecological impacts more comprehensive and standardized, and
- discuss the general implications of this review and analysis for OSWER and identify specific methods development opportunities for selected OSWER programs and activities.

Readers interested in descriptions and evaluations of methodological approaches are directed to Chapters 3, 4, and 5. Those interested in general and specific methods development opportunities and implications for particular OSWER programs and activities are directed to Chapters 6 and 7. Data on the frequency with which specific approaches or their elements were used at CERCLA and RCRA sites, as well as a site-by-site listing of these data, are provided in the accompanying technical Appendices to this report.

Methods reviewed in this report can be divided into three general categories: (1) screening specific sites or facilities, specific waste management practices, and/or general types of facilities or wastes to determine the overall nature and extent of associated ecological impacts in order to establish policy and regulatory priorities, (2) characterizing actual ecological impacts (i.e., those that have been measured or observed) resulting from the release of chemical constituents at these sites or facilities or as the result of these waste practices, and (3) characterizing potential ecological impacts (i.e., those that have not been measured or observed, but are predicted to occur either at present or in the future) that might result from the release of chemical constituents at these sites or facilities or as the result of these waste practices.

Analyses in this report focus primarily on the main approaches used to characterize impacts rather than on details of specific elements used in these approaches. Each major methodological approach is described and evaluated. The evaluation includes the ecological assumptions inherent in the approach, the types of ecological impacts it can and cannot characterize, its main limitations, and its utility for risk management. These approaches then are discussed according to the relative level of effort required and types of information about ecological impacts provided by that level of effort. Opportunities for additional methods development that would make ecological assessments more standardized and comprehensive are outlined. The general implications of this review and analysis for OSWER are discussed. Finally, specific methods development opportunities for particular OSWER programs and activities are identified.

Specific opportunities for methods development are identified for four RCRA programs and four CERCLA programs or activities. The RCRA programs included in this report are: regulatory development, hazardous waste definition and determination, Subtitle C permitting, and Subparts F and S corrective action. The CERCLA programs and activities included in this report are: the Removal program, pre-remedial activities, selection of remedy, and implementation and completion of remedy.

There was considerable variability among OSWER sites reviewed in the approaches and techniques used in ecological assessments, sampling intensity and level of effort devoted to such assessments, and the manner in which particular approaches were applied at a given site. Some of this variability resulted from differences among sites in the need for ecological assessments and types of ecosystems being assessed. Some might have resulted from resource and personnel constraints. However, the general lack of policy and guidance for conducting ecological assessments apparently has resulted in the development of numerous independent approaches in methods used in ecological assessments and in the level of effort and resources devoted to such assessments.

Currently there is no OSWER policy or guidance for selecting for a particular site the appropriate receptors and ecological endpoints of concern; background values and/or reference sampling locations; approaches, techniques, and level of effort; and contaminants of concern. There also is no OSWER policy or guidance for the use of existing toxicity data, interpretation of survey and media toxicity test results, and presentation and discussion of results in site-specific documents. Without clear policy and guidance, evaluations of ecological impacts will continue to vary among OSWER sites. The absence of policy or guidance in many cases is due to a lack of appropriate scientific knowledge and data, and additional fundamental research addressing these data gaps clearly is needed. Policy decisions that could be reached given current knowledge and data are identified in this report.

Without clear policy guidelines, it is not certain whether information about ecological impacts can play a significant role in risk management decisions or the extent to which it should do so. The relative absence of ecological input to remediation and control goals suggests that current approaches, as applied, provide information that is not used in risk management decisions. If information on ecological impacts should play a role in risk management decisions, additional guidance in conducting ecological assessments will be required. Without additional policy and guidance, the information provided by these approaches probably will continue to play a limited role in risk management decisions.

CHAPTER 1

INTRODUCTION

Substances released from sites subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Resource Conservation and Recovery Act (RCRA) have the potential to cause adverse effects to human health and the environment. Although there are numerous examples of adverse ecological impacts being caused by releases of hazardous substances and wastes, programs developed and implemented by EPA's Office of Solid Waste and Emergency Response (OSWER) under CERCLA and RCRA have focused primarily on identification, analysis, and mitigation of potential adverse effects to human health. As a consequence of this program emphasis, relatively little information is available concerning the overall extent of ecological impacts at OSWER sites (EPA/OPA 1989a).

This relative lack of information on ecological impacts appears to result from several factors. EPA has not articulated clear policy guidelines for conducting ecological assessments at OSWER sites, so ecological impacts might not have been evaluated at all sites where such evaluations are warranted. No consistent methodological framework has been developed for evaluating ecological impacts at hazardous waste sites, so a variety of different methods and techniques have been used. No consistent guidelines have been developed for interpreting the results of ecological impact assessments, so these results appear not to have been used consistently in ecological risk management decisions.

To help address these issues, EPA's Office of Policy Analysis (OPA) has initiated a study of the nature and extent of ecological impacts at CERCLA and RCRA sites, the methods that have been or could be used to evaluate ecological impacts at these sites, and past ecological risk management decisions and issues at OSWER waste sites. In this report, the term "ecological assessment" is defined broadly to include any characterization or evaluation of exposure, hazard, risk, or injury to an ecological receptor. The purposes of this report are to:

- identify and summarize the methodological approaches used to characterize both actual and potential ecological impacts at CERCLA and RCRA waste sites,

- identify the ecological assumptions inherent in these approaches and the types of information they can and cannot provide,

- identify opportunities for additional methods development that would make current approaches for characterizing ecological impacts more comprehensive and standardized, and

- discuss the general implications of this review and analysis for OSWER and identify specific methods development opportunities for particular OSWER programs and activities.

OPA has prepared separate reports that evaluate the nature and extent of ecological impacts and past ecological risk management issues at CERCLA and RCRA sites (EPA/OPA 1989a). Taken together, these reports serve as the basis for conclusions on the adequacies of existing EPA policies for ecological protection, opportunities for program improvements, and needs for further development of policy, guidance, and methods.

This report includes a summary and analysis of methods used to characterize ecological impacts in policy and regulatory studies and at specific CERCLA and RCRA waste sites. These methods can be divided into three general categories:

- screening specific sites or facilities, specific waste management practices, and/or general types of facilities or wastes to determine the overall nature and extent of ecological impacts associated with these facilities, wastes, and practices in order to establish policy and regulatory priorities;
- characterizing actual ecological impacts (i.e., those that have been measured or observed) resulting from the release of chemical constituents at these sites or facilities or as the result of these waste practices; and
- characterizing potential ecological impacts (i.e., those that have not been measured or observed, but are predicted to occur either at present or in the future) that might result from the release of chemical constituents at these sites or facilities or as the result of these waste practices.

In this report, evaluation of screening methods is limited to those used in policy and regulatory studies because the specific CERCLA and RCRA sites reviewed had already passed through the screening process before being identified for this study. Hence, site-specific sreening-level models such as the Hazard Ranking System are not evaluated.[1] The analyses presented in this report focus primarily on methods used to characterize impacts that existed prior to response actions, not impacts resulting from responses or remaining after responses have been taken. The report focuses exclusively on impacts associated with releases of hazardous substances and wastes, not impacts caused by other activities at OSWER sites (e.g., construction activities).

There are several important limitations to the analyses presented in this report. First, the review is based primarily on methods as described in site-specific or policy/regulatory documents. Complete documentation for many sites was not readily available, so various types of specific information (e.g., the particular media toxicity test protocol followed) might not have been obtained. Information on ecological impacts and methods was particularly lacking for most types of RCRA facilities (EPA/OPA 1989a). Second, because documentation is necessary to fully describe and evaluate specific methodological approaches and techniques, the review of site-specific methods is concentrated primarily on sites well into the mitigative or control process. Recently-developed techniques or practices were not used at these sites and thus are not described in the documents we reviewed. We have attempted to identify newly-developed techniques and practices during conversations with Regional staff and personnel from other agencies (e.g., the U.S. Fish and Wildlife Service), and we have included at least brief references to some of these techniques and practices in this report. Third, although documents from 52 CERCLA sites and 16 RCRA Subtitle C facilities were reviewed in detail, this sample might not be representative of the full universe of OSWER sites (EPA/OPA 1989). Finally, the detail in which site-specific ecological impacts and methods were described varied considerably among the sites reviewed.

---

[1] See also Section 5.1.

The remainder of this report is divided into six chapters. Chapter 2 outlines the approach taken in this review and analysis. In Chapter 3, methods used to characterize actual site-specific impacts are described and evaluated. In Chapter 4, methods used to characterize potential site-specific impacts are described and evaluated. In Chapter 5, methods used in regulatory and policy studies to characterize the ecological impacts associated with OSWER waste sites are described and evaluated. General opportunities for additional methods development are discussed in Chapter 6. Implications for OSWER and specific methods development opportunities for particular OSWER programs and activities are discussed in Chapter 7.

CHAPTER 2

APPROACH TAKEN IN REVIEW OF METHODS

In this chapter, we outline briefly our approach for identifying and reviewing methods used to characterize ecological impacts at OSWER sites. The approach for site-specific methods is described in Section 2.1, and the approach for methods used in regulatory and policy studies is described in Section 2.2. Criteria used to evaluate methods are presented in Section 2.3.

2.1 Review and Analysis of Site-Specific Methods

Three steps were used to collect and analyze data on the nature and extent of ecological impacts at CERCLA sites: (1) identification of candidate sites with known or suspected ecological impacts, (2) collection of relevant available reports for each candidate site, and (3) review and analysis of the collected reports. Three steps also were used to collect and analyze information on the nature and extent of ecological impacts at RCRA sites: (1) telephone interviews and meetings with RCRA professionals, (2) collection and review of available program analysis and regulatory development documentation, and (3) case study development and analysis of RCRA Subtitle C facilities. Details of the steps taken to identify sites, gather documents, and select sites for detailed review can be found in EPA/OPA (1989). In this section we briefly summarize the process of review and analysis of site-specific documents.

2.1.1 Review and Analysis of Methods used at CERCLA Sites

From a total of 247 CERCLA candidate sites, 52 sites were selected for detailed review based on (a) the presence of some type of ecological assessment, and (b) the quantity and apparent quality of documentation collected for each site. Only those sites for which we obtained at least a Remedial Investigation (RI) report, a detailed Feasibility Study (FS) report, or a detailed risk and/or endangerment assessment were considered.

Information on ecological impacts was extracted from the available site documents. For each site, we recorded the types of contamination and release problems, actual and potential ecological impacts resulting from these releases, and methods used to characterize these impacts. Data on methods are summarized and compiled on a site-by-site basis in the accompanying technical appendices to this report. Information on contamination, releases, and impacts at the same sites is compiled and summarized in EPA/OPA (1989a).

In this report, the phrase actual ecological impacts refers to any adverse effects to individual organisms, populations, communities, or ecosystems that were observed to result from exposure to contaminants released at or from an OSWER site. The phrase potential ecological impacts refers to any such adverse effects that were predicted to result from potential exposures to site-specific contaminants. Actual impacts are evidence that injury to ecosystems or their biotic components has occurred and/or continues to occur at or near the site, while potential impacts are those that (a) might occur but have not yet occurred, or (b) might be occurring at present but have not been observed. For example, actual impacts cannot occur without a release, but potential impacts can be evaluated on the basis of a predicted or potential release. Actual impacts have been distinguished from potential impacts because the methods and data used to characterize the two types of impacts differ markedly. Characterization of actual impacts requires some type of survey or sampling of the condition of ecological receptors at and near the site. Characterization of potential impacts is more predictive in nature and requires information on chemical hazard, exposure potential, and exposure-response for the ecological receptors and methods to predict potential impacts from these data.

2.1.2 Review and Analysis of Methods used at RCRA Sites

The review of RCRA program analyses and regulatory development documents focused on six types of facilities: hazardous waste treatment, storage, or disposal facilities regulated under Subtitle C; municipal solid waste landfills regulated under Subtitle D; coal utilities; smelting and refining facilities; oil and gas facilities; and mining facilities. For most of these areas, available documentation focused on the national extent of ecological impacts and the ranking of comparative risk analyses conducted by EPA Headquarters and several Regions and States (EPA/OPA 1989a).

Review of site-specific methods used at RCRA facilities was limited by temporal constraints and the availability of ecological information to 16 of the 38 RCRA Subtitle C facilities identified through telephone and personal interviews. Information on ecological impacts was extracted from the available documents using the same process as described for CERCLA sites (see Section 2.1.1). Data on methods are compiled on a site-by-site basis in the accompanying technical appendices to this report. Information on contamination, releases, and impacts at the same set of sites is compiled and summarized in EPA/OPA (1989a).

2.2 Review and Analysis of Methods used in Regulatory and Policy Studies

The review of regulatory and policy studies focused on documents from nine studies: (1) Risk-Based Variance from Secondary Containment Requirements of Hazardous Waste Tank Systems (EPA/OSW 1987a), (2) RCRA Risk-Cost Analysis Model (EPA/OSW 1984), (3) the Oil and Gas Report to Congress (EPA/OSW 1987b), (4) the Coal Utilities Report to Congress (EPA/OSWER 1988), (5) the Smelting and Refining Report to Congress (EPA/OSW 1988b), (6) the Mining Wastes Report to Congress (EPA/OSWER 1985), (7) the OSWER Comparative Risk Project (EPA/OSW 1988a), (8) the National Comparative Risk Project (EPA/OPA/OPPE 1987), and (9) the State and Regional Comparative Risk Project (ICF 1987).

From these documents, information on the main approaches used to characterize ecological impacts are summarized (Chapter 4). Each summary includes the purpose of the approach, information on how hazard, exposure, receptors, and risks are characterized, and the main types of information provided by the method.

2.3 Criteria Used to Evaluate Methods

Because there are no clear policy guidelines or standard methods for conducting ecological assessments at OSWER sites, there is no widely-accepted yardstick with which to evaluate a particular methodological approach. We evaluated the methodological approaches with respect to their ecological assumptions, limitations, types of impacts they can and cannot characterize, and utility for risk management. We also determined the relative level of effort associated with each methodological approach and the information gained by that level of effort.

CHAPTER 3

SITE-SPECIFIC METHODS USED TO CHARACTERIZE ACTUAL IMPACTS AT OSWER SITES

In this chapter we describe and summarize the general approaches used to characterize actual, site-specific ecological impacts at CERCLA and RCRA sites and evaluate their effectiveness in characterizing these impacts.

As a preliminary step in this analysis, all methods were organized according to the type of ecosystem (i.e., terrestrial, terrestrial associated with aquatic[2], freshwater, estuarine, marine, and wetland) to which they were applied. For each ecosystem of concern, we determined the types of ecological receptors used to evaluate actual impacts and the general approaches used to characterize these impacts. Receptors were classified according to the biotic level of organization (i.e., ecosystem, community, population, individual), taxonomic group of organism (e.g., bird, mammal, invertebrate, plant), and specific ecological endpoint used (e.g., reproduction, community diversity). Approaches were classified according to the type of method employed (e.g., qualitative survey of the ecosystem, systematic field sampling, media toxicity test), and whether sampling points were selected on the basis of ecological concerns, human health concerns, or both. We also identified the type of ecological benchmark (e.g., lowest-observed-effect level, acute LC_{50}, ambient water quality criterion) used in comparisons with environmental concentrations of contaminants. Such benchmarks, however, do not necessarily reflect actual ecological impacts (see Section 3.1.3). A listing of the frequency with which each element was used at the OSWER sites reviewed is presented in Appendix A, and a site-by-site listing of these elements is presented in Appendix C. These can be found in the accompanying technical appendices to this document.

To provide some background and context for the methods being described and evaluated, we briefly summarize the types of contamination scenarios noted at the OSWER sites reviewed. These scenarios are described in detail in two separate documents (EPA/OPA 1989a). The relative frequency with which contamination of specific media or biota was noted for a given type of ecosystem is shown in Exhibit 1. For example, available documents suggested that actual or potential impacts to terrestrial ecosystems might occur at 35 of the sites reviewed. Contaminated soils were noted at nearly all of these sites, contaminated terrestrial biota was noted at 10 (29%) of these sites, and deposition of airborne contaminants on soils and plant surfaces was noted at nine (26%) of these sites. Contaminated sediments were noted at 32 (58%) of the sites at which available documents suggested that actual or potential impacts to freshwater ecosystems might occur. Overall, contaminated soils, sediments, surface water, and biota were noted frequently at the sites reviewed. The primary routes by which contaminants reached aquatic ecosystems were discharge of contaminated ground water (noted at 24 sites), surface runoff from contaminated soils or other surface materials (22 sites), and direct discharge of leachate (15 sites).

---

[2] An ecosystem in which terrestrial organisms might be exposed to contaminants through direct contact with or ingestion of contaminated surface water or ingestion of aquatic biota.

In the remainder of this chapter, we describe and evaluate the main approaches used to characterize actual ecological impacts at OSWER sites. The three main approaches used to characterize actual impacts are described and evaluated in Section 3.1. A general discussion of approaches and techniques used to characterize actual impacts at OSWER sites is presented in Section 3.2.

3.1 Approaches Used to Characterize Actual Impacts

Actual impacts to one or more types of ecosystems were characterized at 54 (79%) of the 68 OSWER sites reviewed. Three main approaches were used for these characterizations: evaluation of the biotic community structure, analysis of the morphological and/or physiological condition of individual organisms, and comparison of environmental concentrations of contaminants to ecological benchmark levels. The main techniques and endpoints used to characterize actual impacts using these approaches are listed in Exhibit 2. At the majority of sites reviewed, ecological concerns appeared to be driving the evaluations, although at some sites, economic and/or human health concerns (e.g., a finfish or shellfish industry) were evident (see Appendix A).

Evaluation of community structure was used at 37 (69%) of the sites at which actual impacts were characterized (Exhibit 3). This approach was used for terrestrial and wetland ecosystems slightly more frequently than for aquatic ecosystems (Exhibit 4). Analysis of individual morphology and/or physiology was used at 34 (63%) of the sites. This approach was used for aquatic ecosystems more frequently than for terrestrial ecosystems. Comparison of environmental concentrations of contaminants to ecological benchmarks was used at 17 (31%) of the sites. This approach was used only rarely for terrestrial ecosystems. Each of these approaches is described and evaluated in a separate section below.

3.1.1 Evaluation of Biotic Community Structure

Description In this approach, biotic community structure in ecosystems exposed to site-specific contaminants and in nearby reference areas were compared. The purpose was to determine whether a measurable difference in the biotic structure of the exposed ecosystem existed and to document the magnitude of that difference. Measures of community structure included species diversity or evenness indices, stressed or absent vegetation, a qualitative description of the community, and the presence of "indicator" (pollution tolerant) species associated with stressed ecosystems (Exhibit 5). However, specific measures used to evaluate species diversity or stressed vegetation generally were not identified in the documents reviewed.

Three main techniques were used to document community structure (Exhibit 2). On a site-specific basis, the most common technique was systematic field sampling (Exhibit 5). Standardized sampling protocols were used to collect biota, and the taxonomic composition of these biota was evaluated with a diversity or evenness index. This technique was used much more commonly for

EXHIBIT 1

CONTAMINATION SCENARIOS AT OSWER SITES REVIEWED[a]

Type of Ecosystem	Number[b] of Sites	Number of Sites with Documented Contamination[c] of Soil/Sediment	Surface Water	Biota	Air
Terrestrial	35	33	-	10	9
Terrestrial/Aquatic	20	7	5	2	-
Freshwater	55	32	43	27	-
Wetland	27	18	19	11	-
Estuarine	7	7	6	4	-
Marine	2	1	1	0	-

[a] For more detailed information, see EPA/OPA (1988a,b).

[b] The number of sites at which available documents suggested that actual or potential impacts to this ecosystem type might occur.

[c] Numbers do not include sites at which contamination was suspected but not demonstrated.

EXHIBIT 2

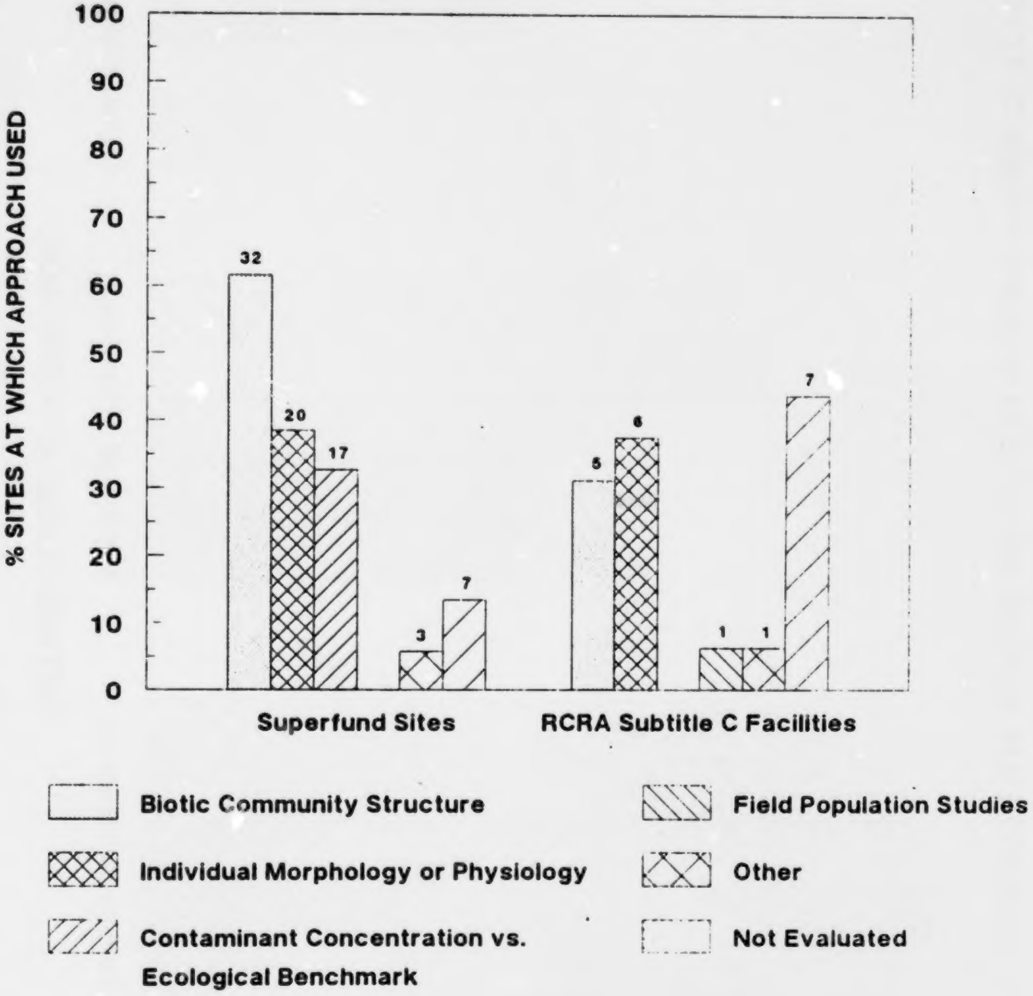
APPROACHES, TECHNIQUES, AND ENDPOINTS USED TO CHARACTERIZE ACTUAL IMPACTS AT OSWER SITES

Approaches	Techniques	Endpoints
Evaluation of Biotic Community Structure	- Quantitative Sampling - Qualitative Surveys - Aerial Photography	- Diversity Indices - Indicator Species - Description of Community - Absent/Stressed Vegetation
Evaluation of Individual Morphology or Physiology	- Field Sampling - Histopathology, Necropsy - Records of Mortality - Detailed Field Studies	- Tissue Residue Levels - Disease/Abnormalities - Reproduction
Comparison of Contaminant Concentrations to Ecological Benchmarks[a]	- Field Sampling	- Contaminated Media - Hazard Indices

[a] Although this approach does not establish the existence of actual ecological impacts, it was used as a surrogate measure of actual impacts at 17 of the sites reviewed.

EXHIBIT 3

APPROACHES FOR CHARACTERIZING ACTUAL IMPACTS AT OSWER SITES



*Number above bar represents number of sites at which approach used.

EXHIBIT 4

FREQUENCY WITH WHICH PARTICULAR APPROACHES WERE USED TO CHARACTERIZE ACTUAL IMPACTS IN SPECIFIC TYPES OF ECOSYSTEMS

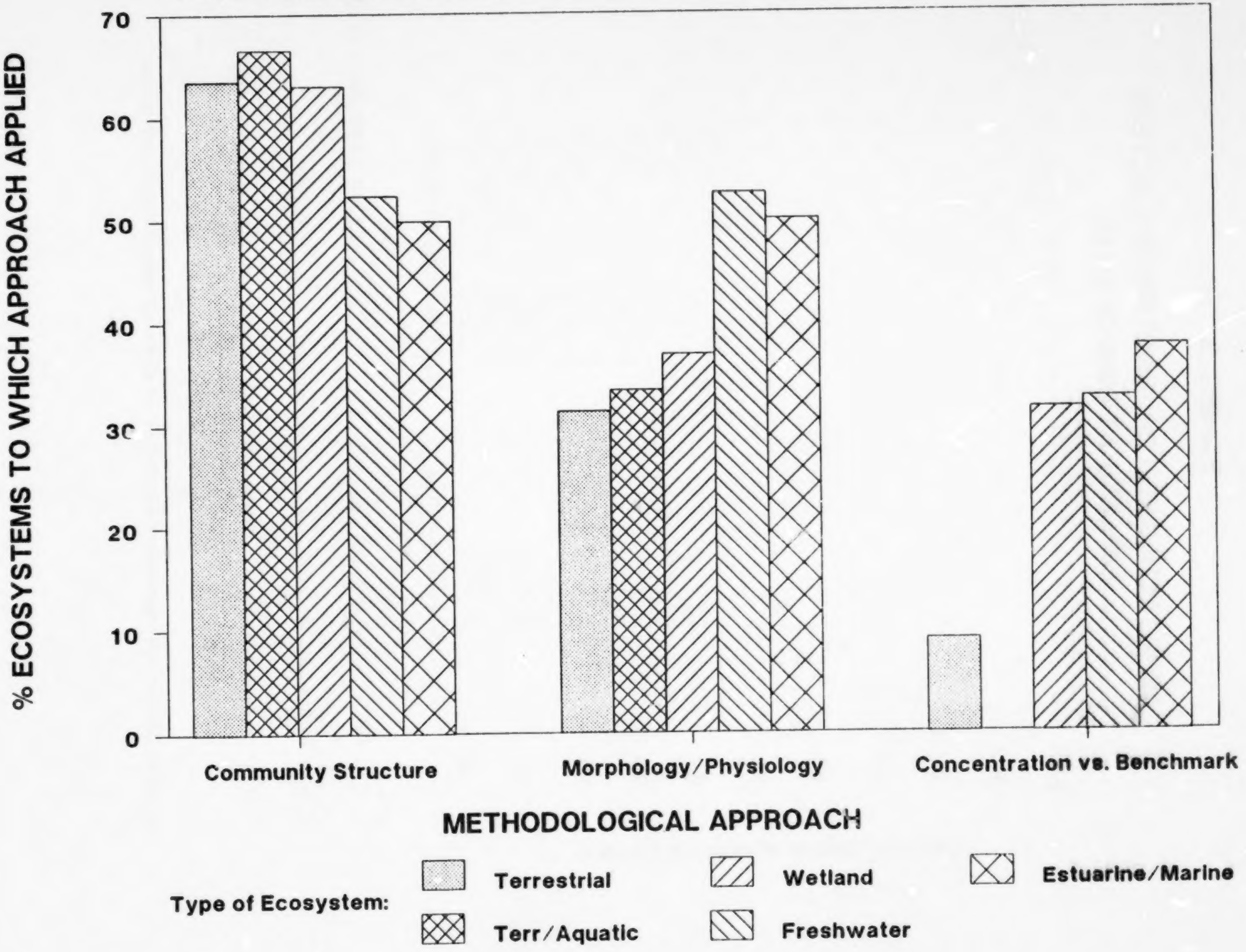
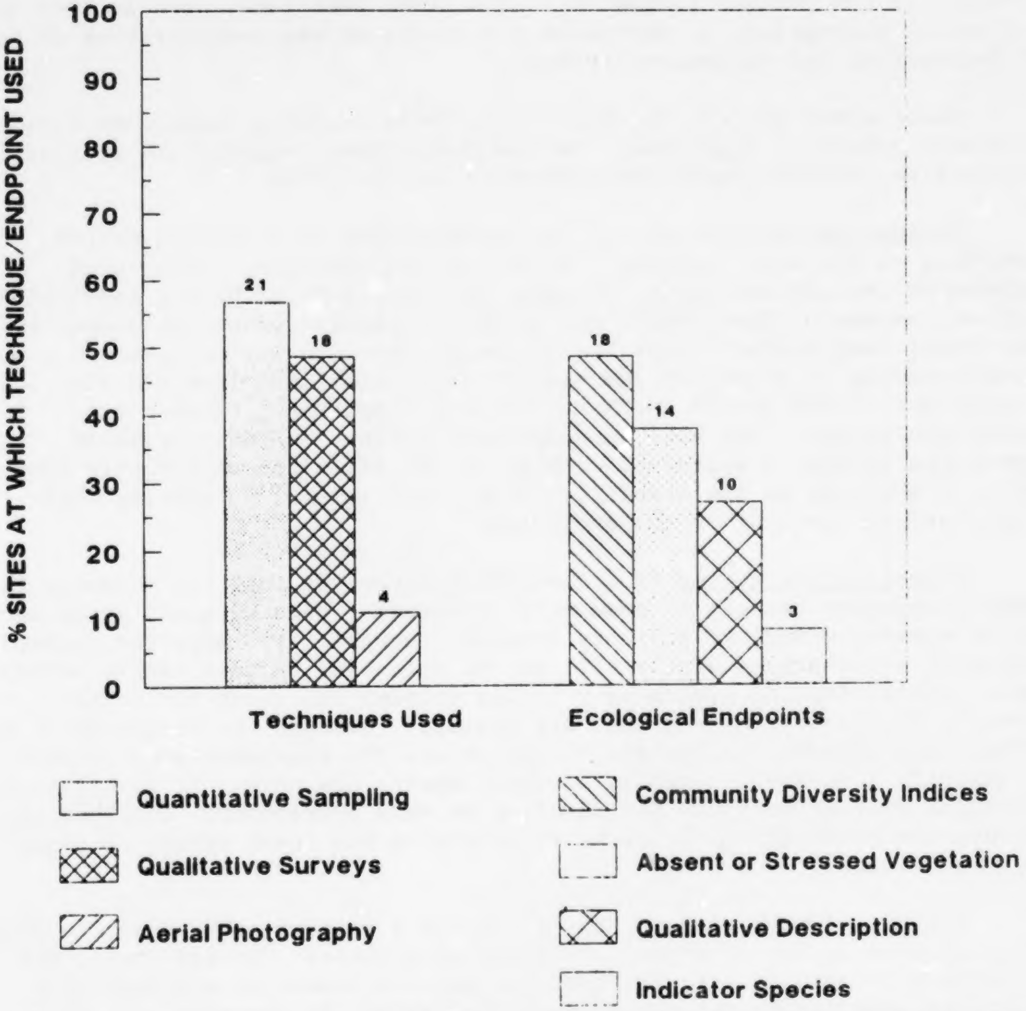


EXHIBIT 5

TECHNIQUES AND ENPOINTS USED TO EVALUATE BIOTIC COMMUNITY STRUCTURE



*Number above bar represents number of sites at which technique or endpoint used.

aquatic ecosystems than for terrestrial or wetland ecosystems. The next most common technique was a qualitative survey of the exposed ecosystem. Such a survey generally was conducted by walking through the area, conducting a census of plants and animals, and noting any differences between the diversity of organisms observed and expected for a "typical" ecosystem of that type. At most sites where this technique was used, the specific reference area used for the comparison was not identified. This technique was used most commonly for terrestrial and wetland ecosystems. The final technique, used at four sites, was aerial photography to determine the extent of vegetation stress or absence in terrestrial and wetland ecosystems.

Qualitative surveys and systematic field sampling focused on four major taxonomic groups of organisms: terrestrial plants, aquatic and terrestrial vertebrates, benthic macroinvertebrates, and shellfish.

Evaluation Ecosystems can be characterized to a certain extent according to two main features: structure and function. Structural components include abundance, biomass, and diversity of biotic populations as well as taxonomic, functional, and trophic organization of the community. Functional components include the processes involved in the movement and transformation of chemicals and energy. Ecosystem structure and function clearly are linked to one another, but in a complex and often poorly understood manner. The basic assumption inherent in diversity-based approaches is that a measurable change in the structure of a biotic community reflects a change in the stability, functional integrity, quality, and likelihood of survival of the ecosystem.

A qualitative survey is a low-effort technique that can document large, readily-apparent changes in community structure. Because qualitative surveys are in essence visual or auditory censuses, subtle, less apparent changes in community structure generally will not be detected. A qualitative survey thus lacks sensitivity and yields very little information about the overall severity of impacts (unless they are obvious), because the magnitude of the differences between the exposed ecosystem and the reference area is difficult to quantify. Moreover, when no adverse impacts are noted, it is difficult to determine whether they had not occurred or were overlooked. Qualitative surveys can be an effective means to determine the areal extent of readily-apparent impacts.

Indices of community structure provide a measure of both subtle and large changes in the structure of biotic communities. In principle, the difference between the structure of the exposed community and that of a reference area can be determined quantitatively. In practice, use of a diversity or evenness index alone rarely provides a measure of the severity of impacts because (a) it is difficult to interpret consequences of a given quantitative change in the index for the stability, functional integrity, quality, and survival of the ecosystem, and (b) the numerical value of the index depends on a number of factors including sampling intensity, seasonality, and the precision with which organisms are identified taxonomically.

Indices of community structure can be extremely effective in characterizing the severity of impacts when coupled with information on the areal extent of such impacts and additional information such as the presence of pollution-tolerant species, although this combination of approaches was not used commonly at OSWER sites. At one atypical site (Palmerton Zinc), diversity indices were used to document the complete devastation of a forested ecosystem, although the presence of impacts was evident even to a casual observer (2,000 acres of trees were defoliated).

Aerial photography is an excellent technique for determining the nature and areal extent of injury to terrestrial and wetland plants. Aerial photographs can provide considerable information about the specific types of injury to plants and the diversity of the plant community, although technical expertise is required to interpret such photographs correctly. However, it is difficult to estimate the severity of damage to vegetation using aerial photography alone. At one site (Wildcat Landfill), aerial photography was used to document the loss or permanent alteration of 31 acres of tidal wetland. In general, aerial photography probably is most effective as a screening technique to identify particular areas for additional surveys or study.

3.1.2 Analysis of the Morphological and/or Physiological Condition of Individual Organisms

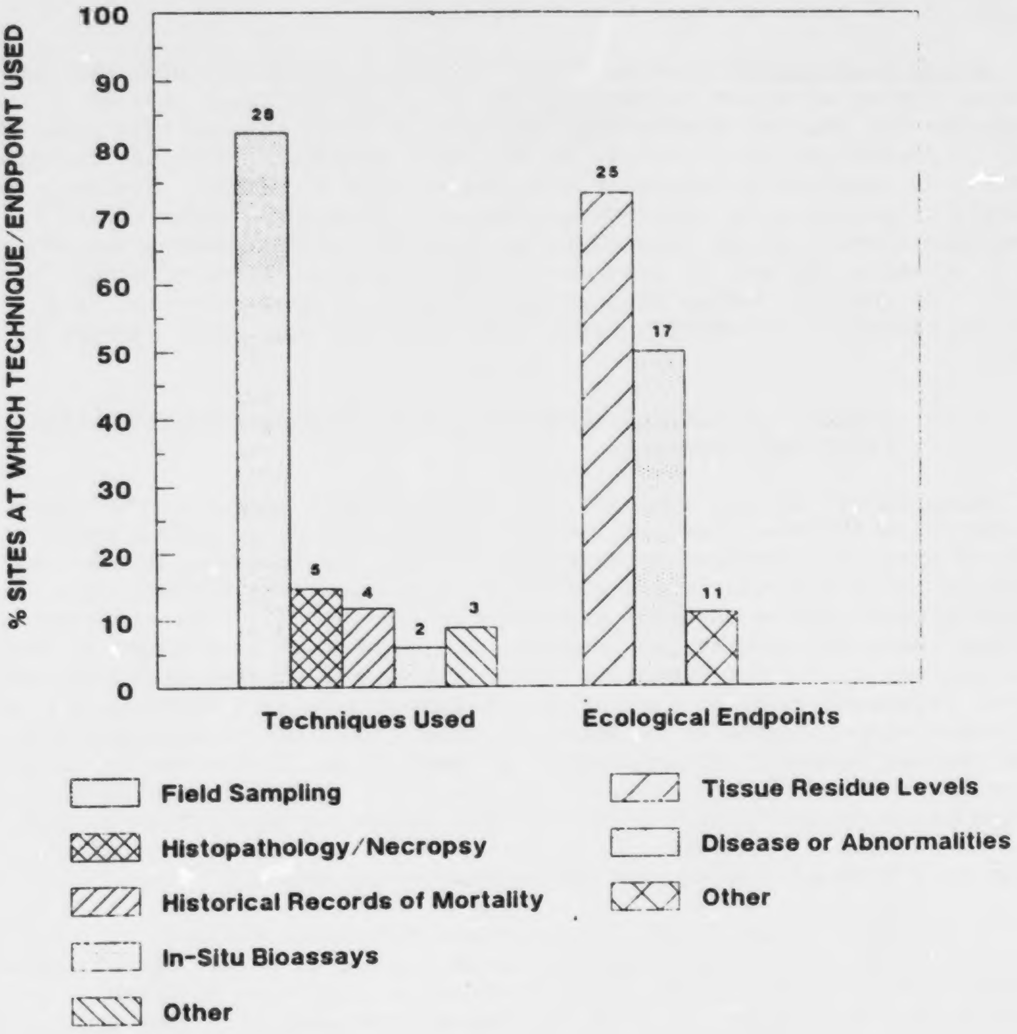
Description In this approach, the physiological and/or morphological condition of individual organisms inhabiting the exposed ecosystem and a reference area were compared to determine whether the incidence of adverse effects in these individuals was greater in the exposed ecosystem. Four main techniques were used to document such effects (Exhibit 2). The most common technique, used for terrestrial, aquatic, and/or wetland ecosystems at nearly all sites, was to collect organisms directly from the exposed ecosystem and from the reference area and examine the collected specimens (Exhibit 6). The most common endpoint used to evaluate the condition of these specimens was tissue residue levels of contaminants. At most sites, tissue residue levels were measured directly in specimens. At two sites, in-situ toxicity tests were conducted to determine whether elevated tissue residue levels in fish were site-related. At one site, data from STORET and a State monitoring program were used for the exposed and reference ecosystems.

At 11 (32%) of the sites, the incidence of tumors, lesions, developmental abnormalities, and other morphological or physiological symptoms of stress were evaluated in specimens (Exhibit 6). At five of these, histopathology or necropsy was used to examine specimens more thoroughly. At four sites, historical records of mortality (e.g., bird carcasses found) were reported for the exposed ecosystem. At one RCRA facility (IRECO Chemicals), field observations were conducted to determine whether predatory birds were able to reproduce successfully.

Sampling and analysis focused on four major taxonomic groups of organisms: aquatic and terrestrial vertebrates, terrestrial invertebrates, terrestrial plants, and benthic macroinvertebrates. Sampling also focused generally on the taxonomic groups most likely to be exposed to contaminants

EXHIBIT 6

TECHNIQUES AND ENDPOINTS USED IN ANALYSIS OF INDIVIDUAL MORPHOLOGY OR PHYSIOLOGY



*Number above bar represents number of sites at which technique or endpoint used.

(e.g., when sediments were contaminated, sampling focused on benthic invertebrates or bottom-feeding fish). Tissue residue levels generally were sampled when substances with a high potential for bioaccumulation were present.

Evaluation The ecological assumptions inherent in this approach depend on its purpose. Individual organisms are the basic biotic components of an ecosystem. Certain organisms (e.g., endangered or commercially important species) also have an economic or aesthetic value. If the purpose of this approach is to determine whether adverse effects have occurred in such "valued" organisms, no ecological assumptions are inherent. Otherwise, this approach assumes that individual organisms are valid surrogates for ecosystem effects (i.e., injury to the basic biotic components of an ecosystem decreases its stability, functional integrity, quality, and/or likelihood of survival).

Measurement of tissue residue levels provides information as to whether biota have been exposed to site-specific contaminants. When background levels of contaminants are high, there can be considerable difficulty in attributing the observed exposure to a site or facility. Strictly speaking, elevated tissue residue levels do not indicate the presence of adverse biological effects unless coupled with independent evidence of such effects. Elevated tissue residue levels simply confirm an exposure. When evidence of actual biological effects is collected, the ecological significance of biotic contamination is more apparent. For example, at the Marathon Battery site, elevated tissue residue levels noted in muskrats were linked at least circumstantially to observed reductions in their reproductive success. Elevated tissue residue levels in organisms that are important food sources (e.g., earthworms, shellfish, fish) also indicate that exposures to other ecological receptors through the food chain are possible. Although rarely done, it is possible to determine the areal extent of elevated tissue residue levels in sessile organisms. For example, at the Allied Chemical Baltimore Works, the areal extent of contaminated shellfish was estimated.

Determining whether adverse morphological or physiological effects are more common in organisms exposed to contaminants than in reference areas is an effective method for characterizing ecological impacts to individual organisms. Only traditional techniques such as gross examination, histopathology, and necropsy were used at the sites reviewed. Newer techniques such as enzyme activity measurement can provide much more sensitive indicators of adverse physiological effects in organisms (see TRI 1987). For example, inhibition of cholinesterase activity in fish and birds indicates that the organism may have been exposed to organophosphate and/or carbamate insecticides. In birds, 51% cholinesterase inhibition has been associated with mortality. Inhibition of delta-aminolevulinic acid dehydratase (D-ALAD) has been correlated with lead uptake in fish and birds. Analyzing effects in individual organisms is particularly effective at distinguishing sites at which impacts have occurred from those at which impacts have not occurred, because the incidence of abnormalities can be compared statistically in the exposed and reference populations. For example, histopathological examination of fish at the Clothier site indicated no significant increase in tumors, parasites, or fin erosion, while increases in the incidence of such abnormalities were noted at other sites.

Use of historical records such as fish kills to document adverse effects can provide evidence that mortality has occurred as the result of past releases from the site, but such records do not provide evidence that mortality or other adverse effects is occurring as the result of present releases. However, when conducting damage assessments at CERCLA sites, the Fish and Wildlife Service considers evidence of past damage even if that damage is no longer occurring. This technique is most relevant if current practices or conditions at the site are identical to those at the time the previous incidents occurred.

3.1.3 Comparison of Environmental Concentrations of Contaminants to Ecological Benchmark Levels

Description In this approach, measured concentrations of contaminants in environmental media (e.g., soil, sediment, and surface water) were compared to ecological benchmark levels derived from toxicity tests on laboratory organisms. The purpose was to determine whether contaminant concentrations had reached a level known to result in adverse effects in these organisms. This approach was used most commonly for aquatic or wetland ecosystems. Ecological benchmarks used most frequently for aquatic ecosystems were the ambient water quality criteria developed by EPA's Office of Water. Those used most frequently for terrestrial ecosystems or the terrestrial component of wetlands were background levels. Usually, no specific organisms or endpoints of concern were identified.

Evaluation Evidence of concentrations of contaminants above benchmark levels confirms the presence of an exposure pathway and the likely magnitude of exposure but does not establish the existence of acutal ecological impacts. For some benchmarks (e.g., ambient water quality criteria), such evidence might be considered a surrogate measure of actual impacts, but it is a more valid measure of potential ecological impacts (see Section 4.1.1).

3.2 General Evaluation of Approaches Used to Characterize Actual Impacts

In the previous section, three approaches for characterizing actual ecological impacts at OSWER sites were identified. Each was evaluated according to its inherent assumptions, the type of information it provided, and its limitations. These approaches are: comparison of environmental concentrations of contaminants to ecological benchmark levels, evaluation of biotic community structure, and evaluation of the morphological or physiological condition of individual organisms. In this section, these approaches are discussed according to the level of effort required and the types of information provided by a given level of effort (Exhibit 7). We also discuss the manner in which these techniques were used to characterize actual ecological impacts at the OSWER sites reviewed.

Comparison of environmental concentrations of contaminants to ecological benchmark levels is a screening-level approach that utilizes information on the areal extent of contamination and the types of ecosystems exposed to contaminants, but it does not provide any information on actual impacts. This is a relatively low-effort approach because information on the nature and

EXHIBIT 7

SUMMARY EVALUATION OF APPROACHES AND TECHNIQUES USED TO CHARACTERIZE ACTUAL IMPACTS AT OSWER SITES

Approach/Technique	Information Provided	Information Not Provided	Information Gained
Evaluation of Biotic Community Structure			
Qualitative Surveys	Identification of large, readily-apparent impacts	Identification of subtle impacts	Identification of sites with major impacts to biotic communities
	Areal extent of impacts	Impacts to individuals or populations	
		Severity of impacts (unless extreme)	
Quantitive Measures	Quantification of small, subtle impacts	Impacts to individuals or populations	Identification of sites with minor impacts to biotic communities
	Severity of impacts[a]		
	Areal extent of impacts		

---

[a] The Ohio Environmental Protection Agency (Ohio EPA 1988) has developed guidelines that define severity of impacts for some ecosystems.

EXHIBIT 7 (continued)

SUMMARY EVALUATION OF APPROACHES AND TECHNIQUES USED TO CHARACTERIZE ACTUAL IMPACTS AT OSWER SITES

Approach/Technique	Information Provided	Information Not Provided	Information Gained
Evaluation of Individual Morphology or Physiology			
Examination of Specimens	Direct evidence of injury to individual organisms Areal extent or magnitude of impacts	Impacts to populations, communities, or the ecosystem	Identification of sites with major impacts to individual organisms
Detailed Field Studies	Quantification of small, subtle impacts to individuals or populations	Impacts to communities or the ecosystem	Identification of sites with minor impacts to individuals or populations
Comparison of Measured Contaminant Concentration to Ecological Benchmarks			
Field Sampling	Nature and areal extent of contamination and/or contamination above benchmarks	Direct evidence of actual impacts	Identification of exposure pathways

extent of contamination generally is required for human health risk assessments and to determine the types of cleanup or controls required at the site. Because this approach is more valid for characterizing potential ecological impacts, it will be discussed in Section 4.1.1 below.

A qualitative survey of community structure can detect large, readily apparent impacts to exposed ecosystems, including the presence or absence of indicator species. It also can be used to determine the areal extent of such impacts. However, more subtle community-level impacts and impacts to populations or individual organisms generally will not be detected with this approach. Severity of impacts is difficult to determine with this technique unless it is obvious.

A quantitative measure of community structure can detect more subtle alterations in community structure. Hence, sites at which community-level impacts are not readily apparent might be identified with this approach. This approach also can provide a measure of the severity of impacts, although it is difficult to evaluate the ecological significance of a particular change in a community diversity or evenness index. Areal extent of impacts can be determined by field sampling or by use of aerial photography.

The quality of information provided by quantitative measures of community structure depends considerably on the scope and intensity of the sampling effort. If one group of organisms (e.g., fish) is of particular interest at a site, sampling focused on that component of the community will provide the most relevant information for that site. Similarly, if a particular group of organisms is known to be very sensitive to the site-specific contaminants, sampling focused on that component of the community might be sufficient to characterize actual impacts at the site. If there is a mixture of chemicals at a site, sampling focused on different components of the exposed ecosystems might be required to detect and fully characterize the nature and extent of impacts to that ecosystem.

The effectiveness of quantitative measures of community structure in characterizing actual impacts depends largely on how well the ecological significance of any observed change in community structure can be documented. For most quantitative measures, there is no scientific consensus on what constitutes an ecologically significant change. Moreover, a change considered significant for one ecosystem might not be considered so for another. The Ohio Environmental Protection Agency (Ohio EPA 1988) has developed criteria for the protection of aquatic ecosystems based on three indices of biotic community structure that offers one means of establishing levels of significance for changes in such measures (see Section 6.7).

Evaluation of the morphological or physiological condition of individual organisms provides direct evidence of whether or not actual impacts have occurred in the organisms of concern, and sufficient sampling can delineate the areal extent or magnitude (e.g., number of individuals or size of population affected) of such impacts. This approach can detect many more subtle impacts to particular organisms or components of the community of concern, and hence can identify sites at which ecological impacts are not limited to changes in community structure, morphology, or physiology. Use of this approach can identify sites at which impacts to individual organisms have occurred but at which community structure is not affected significantly (or the ecological significance of any observed change in community structure cannot be determined).

Morphological or physiological impacts can be evaluated with a variety of techniques ranging in effort from use of historical records of mortality to detailed field studies that require intensive sampling for one or two years at the site and a reference environment. Historical records of mortality can provide evidence of impacts from past releases from a site, but cannot provide evidence of impacts from present releases. Visual examination of specimens collected from contaminated ecosystems can provide evidence of gross injury to individual organisms (e.g., fin erosion, skeletal abnormalities). Additional examination using necropsy or histopathology can provide evidence of other anatomical or physiological injuries. Detailed field studies are required to detect changes in more subtle ecological endpoints (e.g., reproduction, behavior, longevity, demography). The appropriate technique(s) for a given site will be determined to a large extent by the particular contaminants present at the site and the types of ecological receptors exposed to these contaminants.

Evaluation of the morphological or physiological condition of individual organisms is an approach that is complementary to evaluation of community structure. Evaluation of community structure provides little information about individual organisms within that community. Similarly, evaluation of the morphological or physiological condition of individual organisms provides little information about communities within the ecosystem. If there is little reason to expect one type of effect more than the other at a given site, use of both approaches together will identify sites at which effects at one or the other level might be overlooked.

Neither of the above approaches characterizes impacts to biotic populations. Relatively intense field studies generally are required to obtain information on most population-level measures (e.g., density, age structure, survivorship, reproductive rate). Historical records of fish kills were used as evidence of population-level impacts at four Superfund sites, and a field study of the breeding success of predatory birds was conducted at one RCRA facility. Otherwise, no population-level studies were conducted at the sites reviewed.

There is a clear trade-off between level of expense/effort and the amount of information obtained about ecological impacts. Techniques of varying sophistication (and cost) are available for characterizing impacts to organisms and biotic communities, but the most sophisticated technique is not necessarily the most appropriate for a given site. For example, qualitative surveys of community diversity or vegetation stress are appropriate when impacts are obvious or when releases or exposures are highly unlikely, but it might be necessary to follow-up such surveys with systematic sampling to establish the severity of any specific type of impact noted during the survey. Evaluating both community structure and the condition of individual organisms provides a more comprehensive characterization of the types and severity of impacts than does either approach alone. Detailed field studies might be necessary to determine whether particularly valued species are being adversely affected by site-specific contaminants. However, even a comprehensive characterization of impacts does not provide information that can be used directly for determining specific remedial or control actions at a given site. Chemical- or mixture-specific benchmarks are required for establishing such goals (see Section 4.2). Nonetheless, characterization of actual impacts is useful for determining the ecosystems for which cleanup goals are required.

Among the OSWER sites reviewed for this study, there was considerable variability in the type and number of approaches and techniques used, sampling design and intensity, and the extent to which impacts were characterized. Ecosystem- or community-level measures were used exclusively at 12 (22%) of the sites. Individual- or population-level measures were used exclusively at 18 (33%) of the sites. Both were used at 24 (44%) of the sites. At 23 (43%) of the sites, only one approach or technique was used. Two were used at 18 sites (33%), and three or more were used at 19 sites (35%). At most sites, only one or two episodes of sampling or surveying were conducted. Sampling intensity was considerably higher at others. For example, at least four episodes of field sampling were conducted at the Palmerton Zinc site, and 12 separate quantitative samples of aquatic community structure were collected at the Army Creek and Delaware Sand and Gravel sites.

Some of the variability among sites resulted from the type of ecosystem in which impacts were being characterized. More than one approach or technique was used for 11 aquatic ecosystems (23% of all aquatic ecosystems). In contrast, more than one approach or technique was used for only one wetland (5%) and one terrestrial ecosystem (4%). Some variability resulted from the level of assessment required at a given site. For example, at Confidential site # 5, only a simple qualitative survey was required to document several miles of a severely damaged stream ecosystem. Some variability probably resulted from the general lack of policy, guidance, and scientifically proven approaches for characterizing ecological impacts (even in the absence of guidance, a sound ecological assessment method would be used consistently by qualified ecologists). Some probably also resulted from resource and/or personnel constraints.

From the manner in which data and results were presented in the documents reviewed, ecological assessments at most sites probably were conducted by individuals with sufficient ecological expertise. However, at 15 (28%) of the sites, possible impacts that were noted in site-specific documents apparently were not investigated further. At two of these sites (58th Street Landfill and Marion-Bragg), a reason for not investigating these possibilities was given: it was noted that aquatic biota probably were contaminated, but high "background" levels of the contaminant in the receiving waters would make it difficult to link the contamination to the site. At the rest of the sites, there might have been valid reasons for not investigating these possibilities, but these reasons were not provided in the documents reviewed. In addition, most assessments did not adequately incorporate information on the areal extent of impacts, and the ecological significance of observed impacts often was not described clearly at most sites. Again, these inadequacies might have resulted from a lack of policy, guidance, methods, and resources.

CHAPTER 4

SITE-SPECIFIC METHODS USED TO CHARACTERIZE POTENTIAL IMPACTS AT OSWER SITES

In this chapter, we describe and summarize the methods used to characterize potential site-specific ecological impacts at CERCLA and RCRA sites and evaluate their effectiveness in characterizing these impacts.

As a preliminary step in this analysis, all methods were organized according to the type of ecosystem to which they were applied. For each ecosystem of concern, we determined the frequency with which particular elements were used to characterize receptors, hazard, and exposure. Receptors were classified according to the biotic level of organization, taxonomic group of organism, and specific endpoint(s) used. Hazard was classified according to whether contaminants of concern were selected on the basis of ecological risks or human health, the type of site-specific toxicity measures used (i.e., media toxicity tests), and the type of ecological benchmark used. Exposure was classified according to whether sampling points were selected to evaluate ecological or health risks, the exposure pathways considered (e.g., water column, food chain, ingestion of contaminated sediments), the types of assumptions used to estimate intake and/or dose, and how chemical concentrations at the receptor were determined.

Methods also were classified according to which particular approaches to risk assessment were used. Elements of risk assessment included the general type of method used (e.g., qualitative evaluation, quotient method) and how impacts above threshold, areal extent, reversibility of impacts, and uncertainty of the risk assessment were characterized. An analysis of the frequency with which each element was used at the OSWER sites reviewed is presented in Appendix B, and a site-by-site listing of these elements is presented in Appendix D. These can be found in the accompanying technical appendices to this document.

In the remainder of this chapter, we describe and evaluate the main approaches used to characterize potential impacts at OSWER sites. The types of contamination scenarios noted in each type of ecosystem were described previously (Chapter 3). The four main approaches used to characterize potential impacts are described and evaluated in Section 4.1. A general discussion of approaches used to characterize potential impacts at OSWER sites is presented in Section 4.2.

4.1 Approaches Used to Characterize Potential Impacts

Potential impacts to one or more types of ecosystems were characterized at 56 (82%) of the OSWER sites reviewed. Four main approaches were used to characterize potential ecological impacts at these sites: comparison of environmental concentrations of contaminants to ecological benchmark levels (i.e., the quotient method), evaluation of potential impacts from estimates of exposure potential, evaluation of potential impacts from estimates of hazard potential (based on media toxicity test results), and at one site, quantitative modeling to predict the likelihood of adverse effects to the ecosystem. The main techniques and endpoints used to characterize potential impacts using these approaches are listed in Exhibit 8.

Comparison of environmental concentrations of contaminants to ecological benchmarks was used at 45 (80%) of the sites at which potential impacts were characterized (Exhibit 9). This approach was used less frequently for terrestrial ecosystems than for other types of ecosystems (Exhibit 10). Qualitative evaluation of potential impacts from estimates of exposure potential was used at 24 (43%) of the sites. This approach was used more frequently for ecosystems with a terrestrial component than for those with an aquatic component. Evaluation of potential impacts from estimates of hazard potential was used at 14 (25%) of the sites. This approach was used exclusively for aquatic ecosystems and the aquatic component of wetland ecosystems. Quantitative risk modeling was used at one estuarine site. Each of these approaches is discussed in a separate section below.

4.1.1 Comparison of Environmental Concentrations of Contaminants to Ecological Benchmark Levels (Quotient Method)

Description In this approach, concentrations of contaminants in environmental media (e.g., soil, sediment, surface water) or biota were compared to ecological benchmark levels derived from toxicity studies with laboratory organisms. The purpose was to determine whether contaminant concentrations had reached a level known to result in adverse effects in those organisms. Measured or projected contaminant concentrations in the water column are equivalent to exposure levels, at least for aquatic organisms. For contaminants in soils, sediments, and biota, ecological benchmarks generally are based on exposure, and additional information (e.g., bioavailability of contaminants, behavioral attributes of the receptors) is required to estimate exposure from measured or projected concentrations. This discussion includes both concentration- and exposure-based benchmarks.

Ecological benchmarks used most frequently for aquatic ecosystems and the aquatic component of wetlands were ambient water quality criteria (AWQC) developed by EPA's Office of Water[3] and state water quality standards (Exhibit 11). At some sites, additional benchmarks for contaminants in soil, sediments, or biota were derived from chronic lowest-observed-effect levels (LOELs), chronic no-observed-effect levels (NOELs), and acute LC_{50}s or dietary LD_{50}s. At nearly all sites, these benchmarks were applied "correctly" (i.e.,

---

[3] There are four types of EPA-reviewed aquatic toxicity values. For approximately 35 substances, EPA has derived chronic or acute criteria from toxicity tests with a wide variety of species from different taxa. These two types of criteria are designed to protect 95% of aquatic species from chronic and acute adverse effects, respectively. For approximately 60 other substances, data are insufficient to derive acute or chronic criteria, and EPA has identified the lowest identified LC_{50} or lowest-observed-effect-level (LOEL) in the peer-reviewed literature. For most substances, the LOELs are from pre-1980 studies and might be out of date. These two types of values do not offer the same level of protection to aquatic species as do acute or chronic criteria.

EXHIBIT 8

APPROACHES, TECHNIQUES, AND ENDPOINTS USED TO CHARACTERIZE POTENTIAL IMPACTS AT OSWER SITES

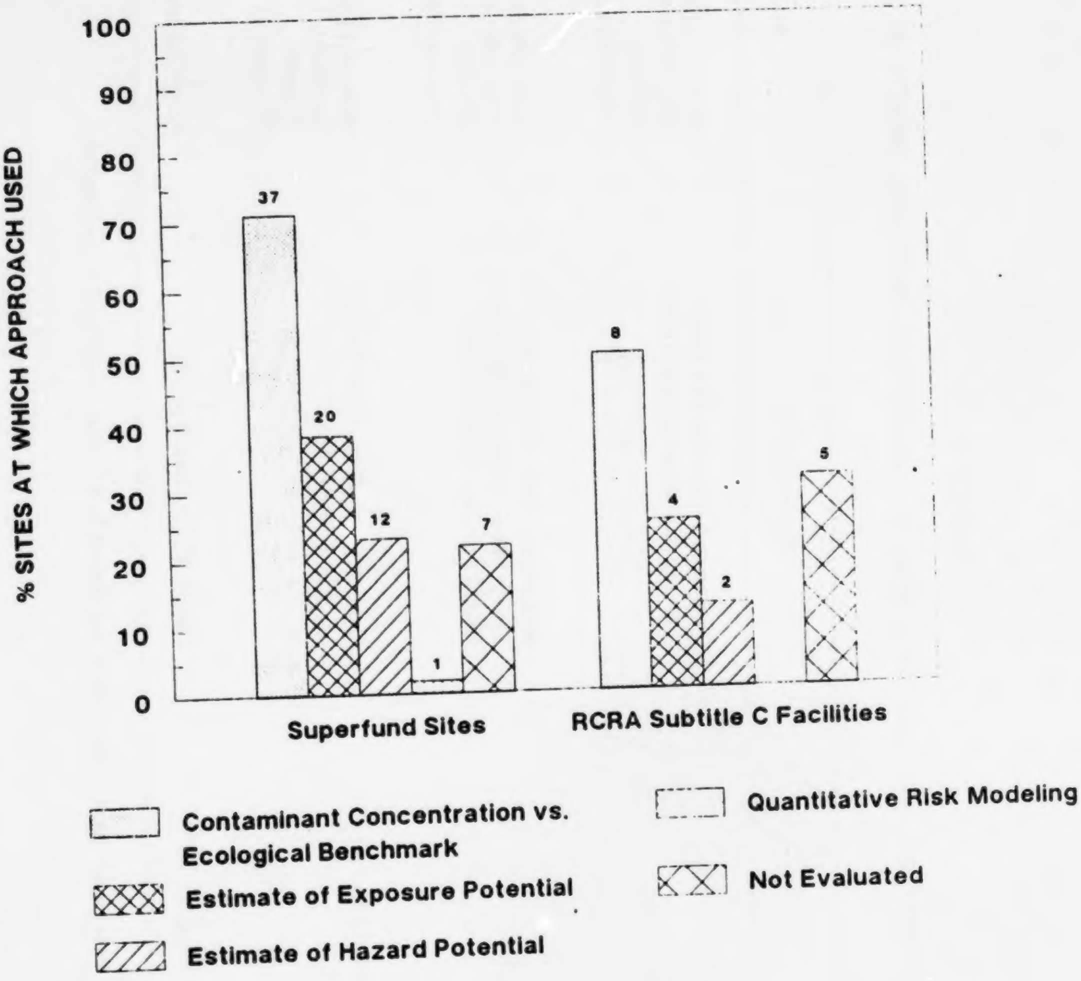
Approach	Techniques	Endpoints
Comparison of Measured and/or Projected Contaminant Concentrations to Ecological Benchmarks	- Measured Concentrations - Projected Concentrations	- Mortality - Reproduction - Growth - Community Structure
Estimate of Exposure Potential (no Benchmark)	- Measured Concentrations - Projected Concentrations - Qualitative Evaluation	- Mortality - Reproduction - Growth - Community Structure
Estimate of Hazard Potential (Media Toxicity Tests)	- Laboratory Toxicity Tests - In situ Toxicity Tests	- Mortality - Reproduction - Growth - Tissue Residue Levels
Quantitative Risk Modeling	- Fault-Tree Analysis[a/]	- Fish Reproductive Failure

---

[a/] The specific model used was not described in detail in the available documents.

EXHIBIT 9

APPROACHES FOR CHARACTERIZING POTENTIAL IMPACTS AT OSWER SITES



*Number above bar represents number of sites at which approach used.

EXHIBIT 1Q

FREQUENCY WITH WHICH PARTICULAR APPROACHES WERE USED TO CHARACTERIZE ACTUAL IMPACTS IN SPECIFIC TYPES OF ECOSYSTEMS

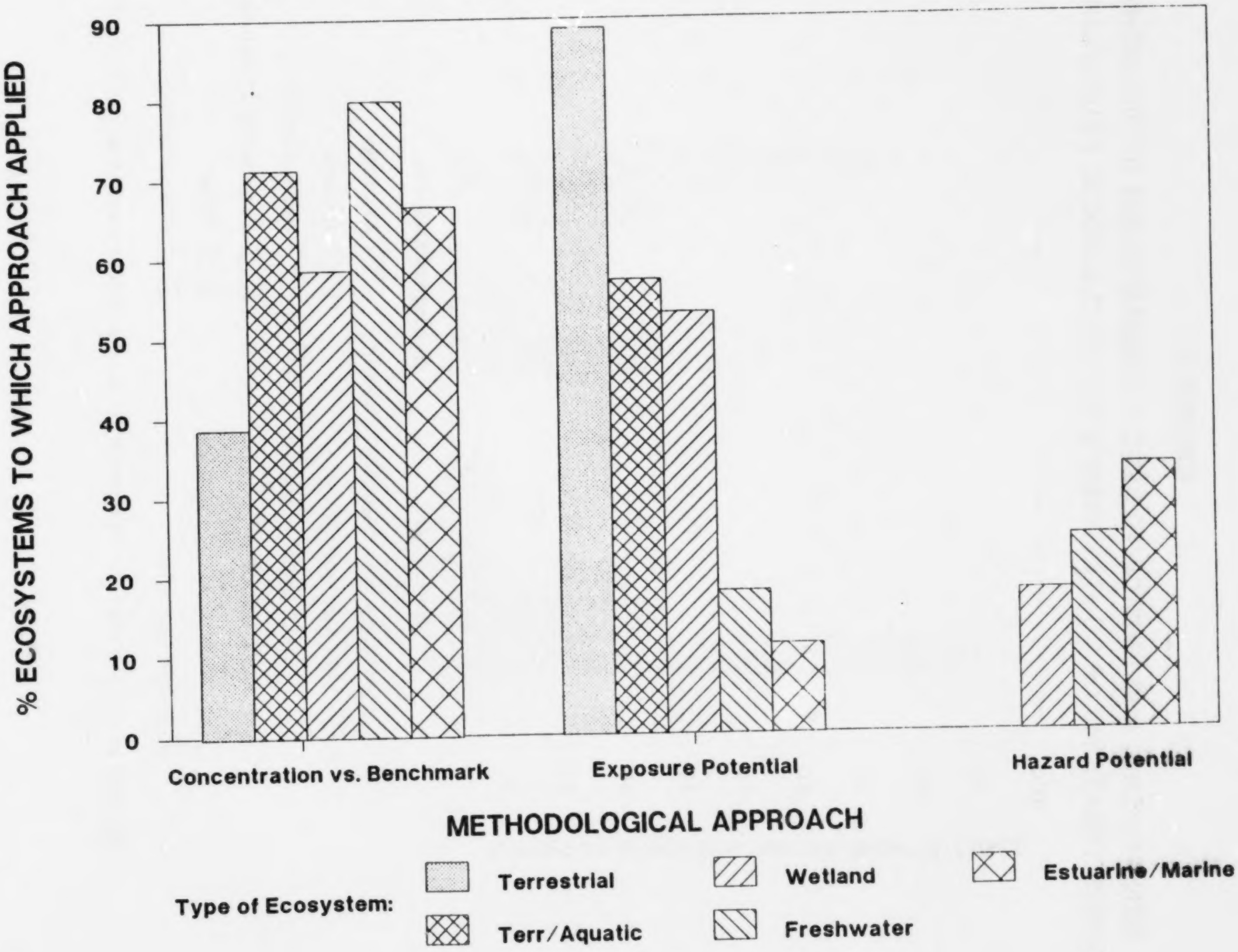
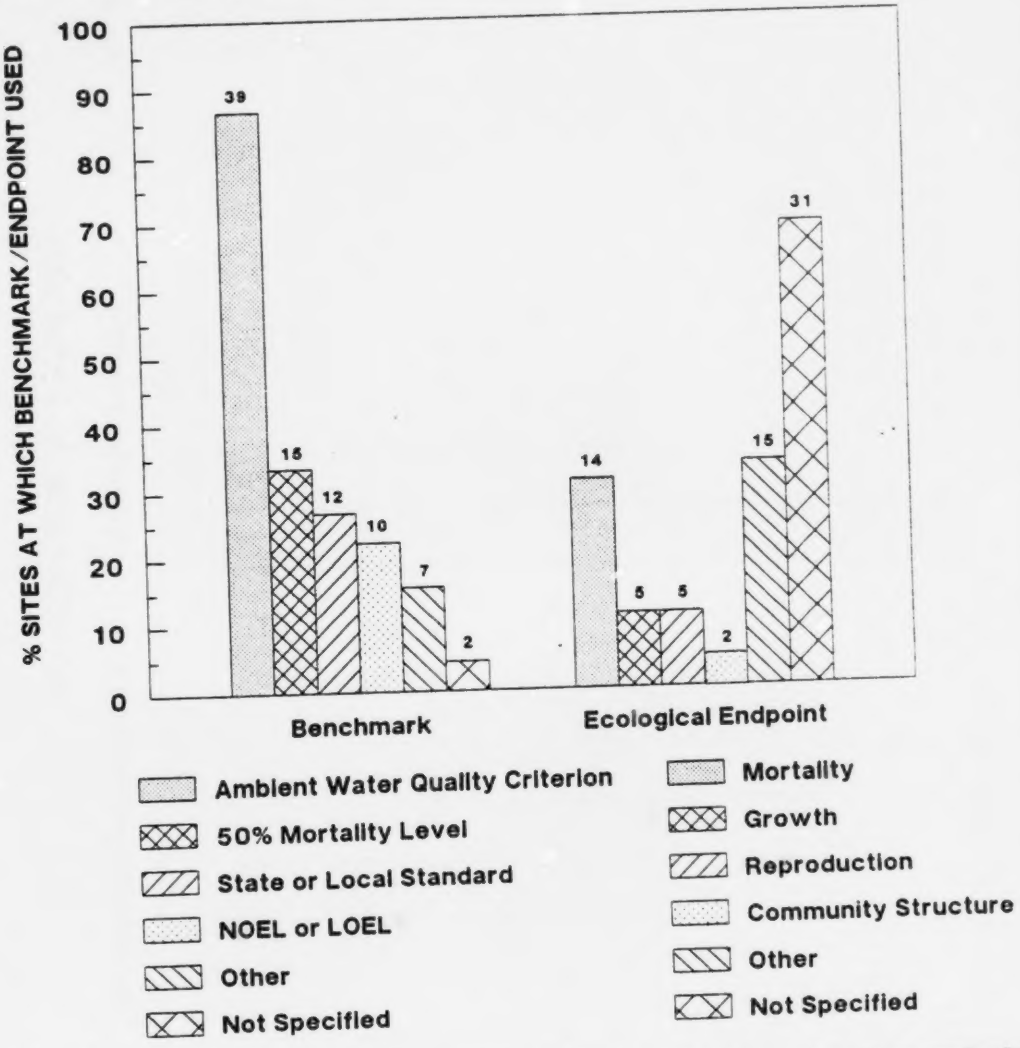


EXHIBIT 11

BENCHMARKS AND ENDPOINTS USED IN COMPARISONS OF ENVIRONMENTAL CONCENTRATIONS OF CONTAMINANTS WITH ECOLOGICAL BENCHMARK LEVELS



*Number above bar represents number of sites at which benchmark or endpoint used acute benchmarks were used to assess impacts from acute exposures). However, at only a few sites were safety factors applied to acute or chronic toxicity measures to adjust for species sensitivity differences and/or acute-to-chronic ratios.

At most sites, no specific ecological endpoints were identified in the documentation (Exhibit 11). AWQC are based on population-level effects but are designed to protect aquatic ecosystems. At sites where endpoints were specified, population-level endpoints in vertebrates and invertebrates (e.g., excess mortality, depressed growth or reproduction) were selected most frequently. Endpoints at the community level were selected less frequently; there are few ecological benchmarks for endpoints at this level of organization.

Concentrations of contaminants at receptors were measured directly in the medium, were projected or modeled (e.g., discharge of contaminated ground water to surface water), or were calculated using information on contaminant bioavailability and behavioral attributes of the consumers (e.g., dietary levels of contaminants in consumers). The quotient method was used to determine whether measured, projected or calculated concentrations of contaminants were found or predicted to exceed the ecological benchmark. When concentrations in excess of benchmark levels were found, there generally was no discussion of the magnitude of the exceedance or possible severity of impacts. Thus, potential impacts generally were characterized in a dichotomous manner (i.e., adverse impacts were or were not likely). In the reports reviewed, there usually was little discussion of areal extent, reversibility, and uncertainty (see Appendix B).

Evaluation Ecological benchmarks generally are derived from laboratory toxicity studies using a variety of species from different taxonomic groups. The responses of individual organisms (e.g., death, reproductive impairment) generally are expressed as measures of impacts to populations (e.g., mortality of 50% of the population, reproductive impairment in some members of the population). Unless the purpose is to determine the likelihood of adverse effects in a population of "valued" organisms, the inherent assumption is that population-level effects are valid surrogates for ecosystem-level effects (see Section 3.1.2). For a few contaminants, benchmarks based on altered community structure are available in the literature.

There are several inherent limitations to the quotient method. First, EPA-reviewed benchmarks (AWQC) are available for only a limited number of substances found frequently at high concentrations at OSWER sites[4]. Chronic benchmarks are based on toxicity tests using a variety of ecological endpoints, some chronic criteria are adjusted for bioconcentration potential, and some are adjusted because the chemical is particularly toxic to algae. Although toxicity measures for aquatic organisms are available in the original literature for a much larger number of chemicals, such measures are based on a variety of test conditions, organisms, and endpoints. Second, this approach does not consider the impacts of the additive, synergistic, or antagonistic effects of exposure to multiple chemicals, which is the usual situation at OSWER sites. Third, widely-reviewed benchmarks are not available for contaminants in air, soils, or sediments. Hence, to use the quotient method for these media, site-specific benchmarks must be derived. Fourth, concentration levels at which substances can be quantified accurately in environmental media are greater than benchmark levels for many substances. For example, the concentration level protective of ecological receptors is below the concentration level quantifiable by current technology as specified by the CERCLA or RCRA program for approximately 30 percent of those substances with EPA-identified benchmarks for the protection of aquatic organisms (ICF 1988b). Finally, this approach does not provide a means to estimate the severity of impacts when the benchmark levels are exceeded.

---

[4] EPA-identified toxicity measures for aquatic organisms are available for only about half of all substances found frequently at high concentrations at CERCLA and RCRA sites, and chronic ambient water quality criteria are available for less than 15 percent of these substances (ICF 1988a).

Comparison of environmental concentrations of contaminants to ecological benchmarks provides information on whether adverse ecological impacts might occur. In principle, information on the nature and areal extent of these potential impacts can be provided by this approach. For example, EPA's Office of Water's Water Quality Criteria Documents provide considerable information on the specific types of adverse effects associated with each contaminant and the organisms in which these effects have been noted. If these potential effects are linked to the particular organisms present in the ecosystem of concern, the nature of the potential impacts to the ecosystem might be determined more specifically. The areal extent of contamination above benchmark levels also can be measured or estimated. In practice, this information was rarely provided.

In principle, the quotient method also can provide some qualitative information on the relative likelihood and severity of adverse impacts. If concentrations of contaminants exceed benchmark levels by an order of magnitude, it is more likely that adverse impacts will occur than if the exceedance is by a few percentage points; it also is likely that the effects will be more severe. Similarly, if exceedances are noted for multiple contaminants, it generally is more likely that adverse effects will occur than if an exceedance is noted for only one contaminant. Finally, if measured or calculated concentrations are compared with an exposure-response curve, information on impacts above (or below) benchmark can be obtained. In practice, this information rarely was utilized at the sites reviewed.

4.1.2 Qualitative Evaluation of Potential Impacts from Estimates of Exposure Potential

Description Qualitative evaluation of potential impacts from estimates of exposure potential consisted of three components: an estimate of exposure potential, a description of the types of ecological receptors likely to be exposed, and a discussion of the types of impacts that might occur in those receptors. This approach differs from the quotient method primarily because no ecological benchmark is used to determine a threshold level of exposure.

Three techniques were used to estimate exposure potential (Exhibit 8). At 13 sites, measured or modeled concentrations of contaminants were found in excess of background concentrations in soils, sediments, or other media for which no widely-accepted ecological benchmarks have been established (Exhibit 12). It was assumed that ecological receptors would be exposed to these contaminants, and the types of impacts to those receptors were described, but the likelihood of such impacts was not evaluated. At nine sites, the specific contamination scenario was such that the likelihood that ecological receptors would be exposed to site-specific contaminants was considered to be low (e.g., the areal extent of contamination was extremely small or the likelihood of release was very low), so there was little effort to evaluate or characterize potential ecological impacts. At six sites, potential contamination of nearby ecosystems was noted, but no sampling or fate-and-transport analysis had been conducted for those ecosystems, so the likelihood of contamination could not be determined. Again, potential receptors and impacts were described in general, but the likelihood of such impacts was not evaluated.

Endpoints selected most frequently were excess mortality, depressed reproduction or growth, and changes in community structure (Exhibit 12). Specific receptors identified most frequently were birds, mammals, and plants, but at most sites, endpoints and organisms were not specified. There was virtually no discussion of the severity, areal extent and reversibility of impacts, and the uncertainty of the characterization.

Evaluation The basic assumption of this approach is that the likelihood of adverse ecological effects is related to the likelihood of exposure. Because no benchmark is used, the main information provided by this approach is the likelihood that ecological receptors will be exposed to site-specific contaminants and the types of adverse impacts that might occur as a result. No information is provided as to (a) whether these potential exposures will be at levels sufficient to result in adverse impacts, and (b) how severe these impacts might be. Moreover, the evaluation of potential impacts is largely subjective. In principle, information on the areal extent and reversibility of the potential impacts can be provided, but in practice this information rarely was provided.

4.1.3 Evaluation of Potential Impacts from Estimates of Hazard Potential

Description In this approach, potential ecological impacts were evaluated based on media toxicity tests (Exhibit 8). Two types of media toxicity tests were used (Exhibit 13): laboratory toxicity tests, in which organisms are exposed to contaminated media in a controlled laboratory setting, and in situ toxicity tests, in which organisms are exposed to contaminated media in the field. The purposes were to determine what adverse effects would result from such exposures, and/or the potential for uptake and bioconcentration of contaminants. Toxicity tests were conducted using sediments, leachate, and surface water. Organisms used in the laboratory toxicity tests were fish (e.g., fathead minnows, Pimephales promelas), daphnids (e.g., Ceriodaphnia, Daphnia), and bacteria. Fish and shellfish were used in the in situ toxicity tests.

EXHIBIT 12

TECHNIQUES AND ENDPOINTS USED IN QUALITATIVE EVALUATION OF POTENTIAL IMPACTS BASED ON ESTIMATES OF EXPOSURE POTENTIAL

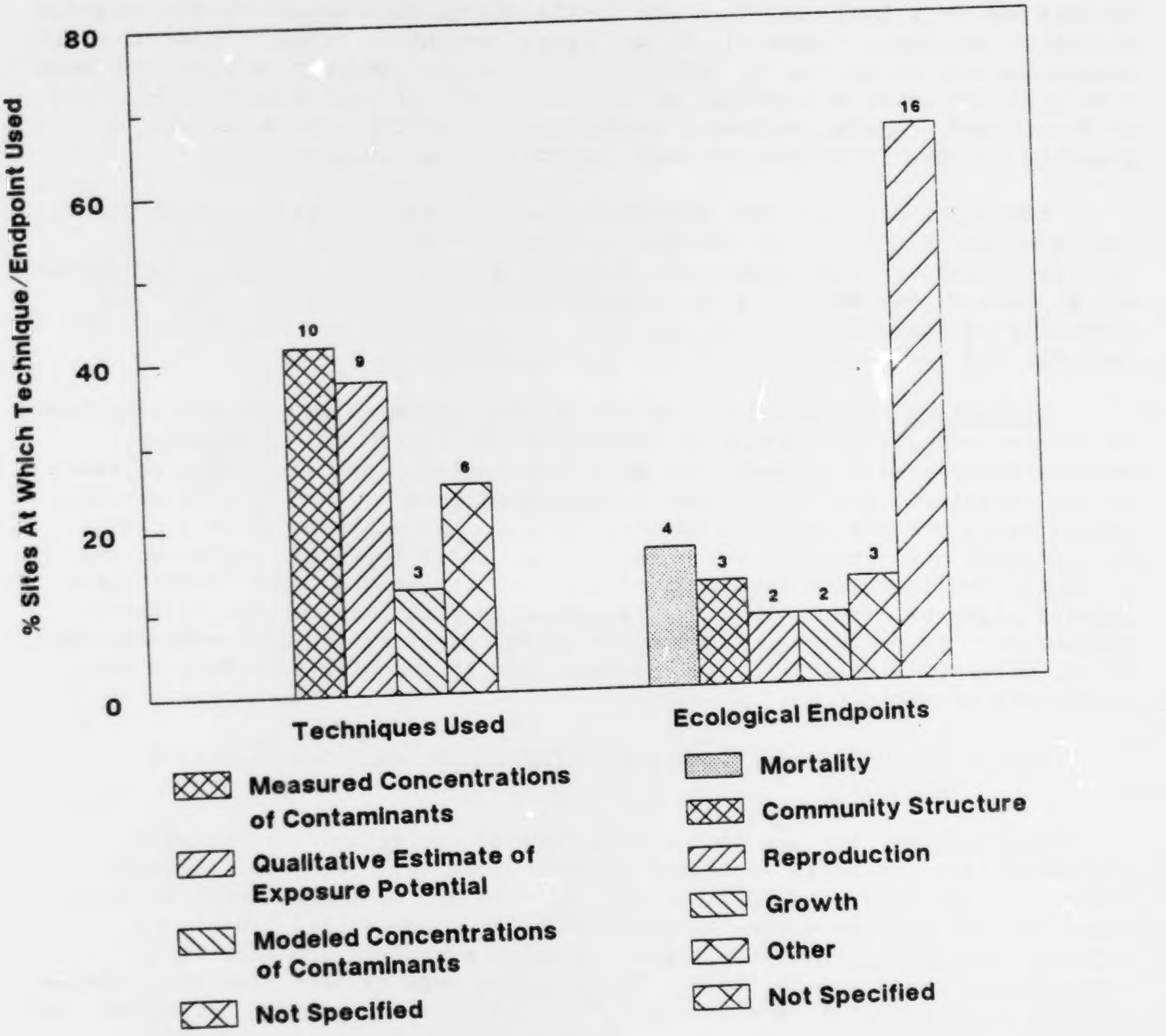
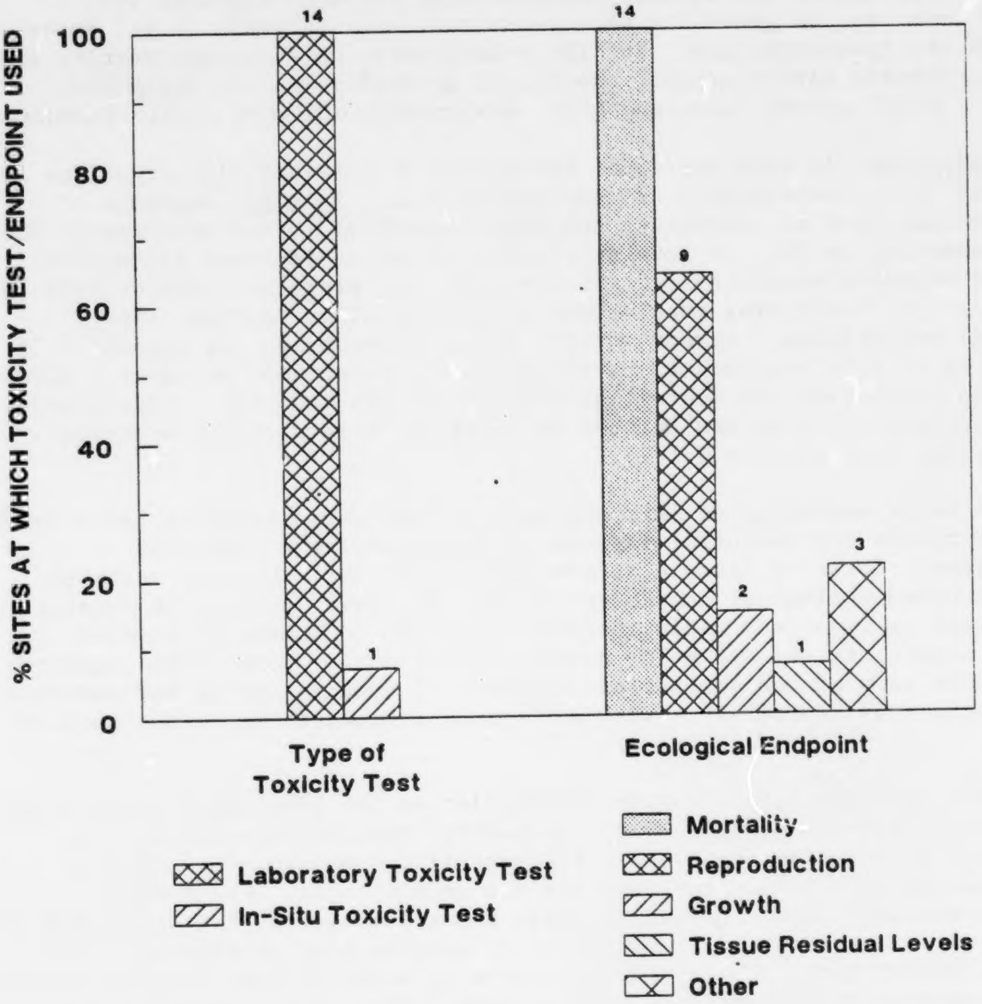


EXHIBIT 13

TYPES OF TOXICITY TESTS AND ENDPOINTS USED IN EVALUATION OF POTENTIAL IMPACTS BASED ON ESTIMATES OF HAZARD POTENTIAL



Endpoints used were either at the population level (e.g., excess mortality, depressed reproduction, decreased bacterial bioluminescence [an indirect measure of mortality]) or at the individual level (e.g., tissue residue levels) [Exhibit 13]. The specific toxicity test protocols used usually were not described, although several standardized protocols were referenced. Among the sites reviewed, this approach was used exclusively for aquatic ecosystems or the aquatic components of wetlands (Exhibit 10). Toxicity test results generally were presented quantitatively (e.g., mortality of 85% of the test organisms), but the relationship between such results and potential impacts within exposed ecosystems generally was not described clearly.[5] Areal extent, reversibility, and uncertainty were rarely discussed.

Evaluation In this approach, laboratory or site-specific organisms in controlled (i.e., laboratory) or constrained (i.e., in situ) exposure conditions are used as surrogates for other organisms in the ecosystem. The basic assumption is that if adverse effects are noted in these surrogates under the exposure conditions of the toxicity test protocol, similar effects would occur in free-living populations of site-specific species. The ecological assumptions inherent in this approach depend on its purpose. If the purpose of this approach is to determine the likelihood of adverse effects in "valued" organisms, no ecological assumptions are inherent. Otherwise, population-level effects are assumed to be valid surrogates for ecosystem-level effects (see Section 3.1.2).

The major advantage of this approach is that media toxicity tests can be used to evaluate the potential impacts of site-specific mixtures of contaminants. Toxicity tests also are appropriate for media for which no widely-accepted ecological benchmarks exist. Moreover, because no chemical quantitation is required, media toxicity tests can be conducted even if chemical concentrations are below quantitation limits. Hence, this approach can overcome many of the limitations inherent in comparisons of environmental concentrations of contaminants with ecological benchmarks (i.e. the quotient method).

Media toxicity tests provide information on the likelihood and severity of particular adverse effects (e.g., mortality, reduced reproduction) to populations of organisms exposed to site-specific contaminants. However, interpretation of toxicity test results can be difficult. For example, mortality was very high in toxicity tests using leachate at two sites, but it was concluded that it would be difficult to ascribe similar effects in organisms inhabiting nearby receiving waters to leachate from the site because of other sources of pollution in those waters. Similarly, at another site (Marathon Battery), the mortality of fish from a nearby population exposed in situ to contaminated water was greater than that observed in a local population of the same species of fish living in the contaminated water, suggesting that the local population had adapted to site-specific contaminants. Moreover, "acceptable" levels of impacts observed in a given toxicity test were not provided at any site, although current NPDES permit guidelines (EPA/OW 1985,1988) were not referenced (see also Section 6.4). Hence, it was not possible to determine the difference between the observed results and "acceptable" levels.

---

[5] EPA policy on significant effect levels in media bioassays was described recently for the NPDES permitting process (EPA/OW 1985, 1987). This policy was not referenced in any site documents reviewed.

4.1.4 Quantitative Modeling of Adverse Effects to Ecosystem

Description At one site (Confidential # 1), a mathematical model was used to evaluate the likelihood of a significant impact to the ecosystem (i.e., catastrophic failure of fish reproduction). This model incorporated a fault-tree analysis of reproductive failure resulting from mortality, decreased population density, insufficient food, and failure of eggs to hatch. At this site, sediments and biota were contaminated with PCBs. The likelihood that fish would fail to reproduce in the ecosystem was modeled using an assumed food web, exposure/intake assumptions, and bioconcentration factors. Specific details of the model and its assumptions were not provided in the available documents.

Evaluation It is difficult to evaluate this approach because the particular model used at the one site was not described in detail in the available documents. The information provided was a specific probabilistic statement of the likelihood of a significant impact to the ecosystem (catastrophic failure of fish reproduction). The level of effort required to produce and apply the model clearly was very high. This effort probably was undertaken because a substantial fish and shellfish industry was affected by the site. Such an effort may be beyond the scope of most site-specific evaluations of potential ecological impacts.

4.2 General Evaluation of Approaches Used to Characterize Potential Impacts

In the previous section, four approaches for characterizing potential impacts at OSWER sites were identified and evaluated. These are: comparison of environmental concentrations of contaminants to ecological benchmark levels, qualitative evaluation of potential impacts from estimates of exposure potential, evaluation of potential impacts from estimates of hazard potential, and quantitative modeling of adverse effects to ecosystems. In this section, these approaches are discussed according to the level of effort required and the types of information provided by that level of effort (Exhibit 14).

A qualitative evaluation of exposure potential provides information on the types of ecosystems and organisms that might be exposed to site-specific contaminants and the possible types of impacts that might result, but it does not provide any information on the likelihood, severity, or ecological significance of such impacts.

Comparison of environmental concentrations of contaminants with ecological benchmarks provides dichotomous (yes/no) information on whether adverse ecological impacts are likely. This approach provides little information about the severity of effects if benchmark concentrations are exceeded, although higher rates in general will be correlated with more severe impacts. This approach also provides little information on the effects resulting from exposure to multiple contaminants.

EXHIBIT 14

SUMMARY EVALUATION OF APPROACHES USED TO CHARACTERIZE POTENTIAL IMPACTS AT OSWER SITES

Approach/Technique	Information Provided	Information Not Provided	Information Gained
Comparison of Measured and Projected Contaminant Concentrations to Ecological Benchmarks	Yes/no information as to whether impacts are likely	Quantitative measure of severity of impacts if benchmarks are exceeded	Ecologically based cleanup criteria for single contaminants
	Impacts resulting from direct exposures to contaminated media and indirect exposures via food chains	Impacts to communities or the ecosystem (unless benchmarks specifically account for these)	
Estimate of Exposure Potential	Types of ecosystems and receptors potentially exposed to contaminants	Likelihood or severity of potential impacts	Identification of sites with potential ecological Identification of potential exposure pathways

EXHIBIT 14 (continued)

SUMMARY EVALUATION OF APPROACHES USED TO CHARACTERIZE POTENTIAL IMPACTS AT OSWER SITES

Approach/Technique	Information Provided	Information Not Provided	Information Gained
Estimate of Hazard Potential (Media Toxicity Tests)	Quantification of likelihood and severity of impacts to populations of test organisms Identification of hazards to site-specific populations Areal extent of impacts (if media tested at sufficient number of locations)	Impacts to communities or the ecosystem	Ecologically-based cleanup criteria for mixtures of contaminants[a] Ecologically-based cleanup criteria for contaminants in soils and sediments
Quantitative Risk Modeling	Likelihood of specific impacts to individual organisms, populations, communities, or the ecosystem Severity of impacts Areal extent of impacts	not known[b]	Quantification of ecological risks for risk management decisions

---

[a] NPDES permit guidelines (EPA/OW 1985, 1987) define toxicity test-based cleanup criteria for some ecosystems.

[b] The specific model used was not described in detail in the available documents.

Within this general approach, there numerous specific techniques are available. Each provides different types of information. Evaluating measured or projected contaminant concentrations in media provides information about potential impacts resulting from exposures via direct contact with such media. Calculated contaminant concentrations at various trophic levels in a food chain provides information about impacts resulting from indirect exposures. Calculated exposure levels in receptors from measured or projected contaminant concentrations in biota and/or media such as sediments or soils allows incorporation of additional information (e.g., bioavailability of contaminants, behavioral attributes of receptors) critical to evaluating potential impacts. Evaluations could be limited to substances with widely-accepted ecological criteria (i.e., AWQC), or they could include site-specific benchmarks for additional substances that are derived from other toxicity data. Evaluations could consider each substance singly, or could incorporate hazard indices to evaluate potential effects from exposure to multiple chemicals. As more of the above techniques are incorporated into this approach, the likelihood of detecting a site with potential ecological impacts will increase.

Toxicity tests provide information on the likelihood and severity of particular adverse effects to populations of organisms exposed to site-specific contaminants. The results from toxicity tests also can be used to evaluate hazards to site-specific organisms if the test organisms are valid surrogates (e.g., they are particularly sensitive to site-specific contaminants). Toxicity tests are particularly effective at identifying hazardous conditions at sites with complex mixtures of chemicals and at sites where contaminants are present in media for which no widely-accepted benchmarks exist (e.g., soils, sediments). In principle, toxicity tests can indicate the relative severity of potential impacts. For example, the dilution at which an aquatic sample is lethal to 50% of the test organisms is an inverse measure of relative severity. Such information can be used to identify levels of concern for toxicity test results, as has been done for the NPDES permitting program (see Section 6.2.2). At the sites reviewed, levels of concern for toxicity test results were not identified in the available documents.

Use of toxicity tests is an approach that is complementary to comparison of environmental concentrations of contaminants with ecological benchmarks, because each identifies a different aspect of potential ecological impact. The former approach evaluates the bioavailability of and hazards associated with particular mixtures of substances at a site, while the latter approach evaluates the potential impacts associated with specific contaminants of concern. Hence, use of both approaches at a particular site will increase the likelihood of detecting potential ecological impacts.

At present, comparison of environmental concentrations of contaminants to ecological benchmarks can aid directly in the selection of a mitigative remedy because most remedies are chemical-concentration specific (e.g., removal of all soil with concentrations of PCBs above 50 ppm). In principle, toxicity tests also can be used to select a mitigative remedy (e.g., removal of all soil toxic to more than 10% of the test organisms), but in practice a prohibitively large number of tests might be required (e.g., to define the three-dimensional boundaries of the area to be remediated).

Quantitative risk modeling provides a specific probabilistic prediction of the likelihood of a particular adverse effect in a given ecosystem. At present, there is no widely-accepted methodology for such an approach. It might be possible to develop generalized models for certain contamination scenarios so that only minor adaptations of the model to site-specific conditions would be required. In most cases, however, it probably will be necessary to develop models on a site-specific basis. This is an expensive and time-consuming effort. Quantitative risk modeling probably is the only way to quantitatively evaluate risks to a specific element of an ecosystem (e.g., a commercial fishery) that is of concern at a particular site.

Numerous widely-accepted emissions, transport, and fate models are available at present and could be applied to a variety of terrestrial and aquatic systems to quantify exposure, chemical persistence, and other key risk assessment elements. These models, if incorporated into a tiered and integrated modeling/data collection and analysis process, could provide more accurate risk estimates in a resource-efficient manner. Exposure models were used a some of the sites reviewed, primarily to estimate chemical concentrations in specific media and biota.

There is a clear trade-off between level of expense/effort and the amount of information obtained about potential ecological impacts. However, the most intensive approach is not necessarily the most appropriate for a given site. For example, qualitative evaluation of impacts from exposure potential is appropriate when releases are highly unlikely, and a quantitative, probabilistic risk assessment might be appropriate only when evaluating impacts to critically important biotic resources. Media toxicity tests might be required to fully determine the potential ecological impacts from exposures to multiple chemicals at a site, but such information might not be required to determine the specific remedial or control actions for the site. Guidance in selecting the appropriate level of effort for a given site is needed.

Within the sample of sites reviewed, there was considerable variability among sites in the number of approaches and techniques used, how specific approaches, particularly the quotient method, were used, and the extent to which potential impacts were characterized. Individual- or population-level measures were used exclusively or in combination with ecosystem- or community-level measures at 55 (98%) of the sites. At 31 (55%) of the sites, only one approach or technique was used. Two were used at 22 sites (39%), and three were used at 3 sites (5%).

Some of the variability among sites resulted from the type of ecosystem in which impacts were being characterized. More than one approach or technique was used for 12 aquatic ecosystems (23% of all aquatic ecosystems) and 5 wetland ecosystems (28%). In contrast, more than one approach was used for only 3 terrestrial ecosystems (11%). Some variability resulted from the level of assessment required at a given site. For example, at Confidential site #5, the only practical remedy was total elimination of contaminant (asbestos) release. Although severe damage had been documented in nearby ecosystems, complete source control would eliminate future damage, so there was little need to characterize potential ecological impacts. In contrast, potential ecological impacts were investigated at the O'Connor site in part to determine whether cleanup of PCB-contaminated sediments in a nearby brook was necessary. Some variability probably resulted from the general lack of policy, guidance, and scientifically proven approaches for characterizing potential ecological impacts and/or from resource or personnel constraints.

The use of the quotient method (i.e., comparison of contaminant concentrations to ecological benchmarks) was especially variable among sites. This variability included selection of contaminants of concern, application of safety factors to toxicity values, derivation of ecological benchmarks for terrestrial ecosystems, and the degree to which contaminant concentrations exceeded benchmarks was used to characterize hazard. At 39 (67%) of the sites, ecological assessments of aquatic ecosystems focused exclusively on substances for which AWQC existed. At the remainder of the sites, substances with other toxicity values, including those from the open literature, were used in the ecological assessment. At all sites the preferred ecological benchmark was a chronic or acute criterion, but at several sites (e.g., Fultz Landfill), substances with an EPA-identified LOEL or lowest-observed LC_{50} were not used in the ecological assessment.

Safety factors were applied at only 8 (33%) of the 24 sites at which a LOEL or LC_{50} was used to derive a benchmark. Specific safety factors also varied among sites. Chronic safety factors applied to an LC_{50} included 1/100 (at four sites) and 1/20 (at one site). Acute safety factors applied to an LC_{50} included 1/3 (at one site) and 1/5 (at one site). A safety factor of 1/10 was used with a LOEL at one site (International Paper Co. Treated Wood Products Plant). At two sites (Tyson's Dump and National Industrial Environmental Services), the benchmark used was the geometric mean of the maximum allowable toxicant concentration (MATC). The MATC was calculated from LC_{50} values in fish using the technique of Suter et al. (1983).

Derivation of ecological benchmarks for terrestrial ecosystems was particularly variable. A LOEL or NOEL was used at six sites, an LD_{50} was used at four sites, and other measures were used at three sites. An acute safety factor of 1/5 was used with an LC_{50} at two of the sites.

For most substances, the greater the degree to which contaminant concentrations exceed the ecological benchmark, the greater the likelihood of adverse ecological impacts. However, the magnitude of exceedance was used to characterize hazard at only one site (Liquid Disposal). At other sites, no distinction was made between situations in which the measured or modeled exceedance was relatively small (e.g., a few percentage points) and those in which it was high (e.g., more than one order of magnitude greater).

From the manner in which data and results were presented in the documents reviewed, ecological assessments at most sites probably were conducted by individuals with sufficient ecological expertise. However, at 26 (38%) of the sites, information in site-specific documents suggested that potential impacts in some ecosystems or via some exposure pathways were not investigated. At most of these sites, the reasons for not investigating these potential impacts were not given in the documents reviewed. In addition, most assessments did not adequately incorporate information on the areal extent or reversibility of impacts, the uncertainty of the characterization, and the societal or ecological significance of the potential impacts (see Appendix D). Again, these inadequacies might have resulted from a lack of policy, guidance, methods, and/or resources.

CHAPTER 5

METHODS USED IN REGULATORY AND POLICY STUDIES TO CHARACTERIZE ECOLOGICAL IMPACTS AT OSWER SITES

In this chapter, we describe and summarize the methods used to characterize ecological impacts at OSWER sites in regulatory and policy studies and evaluate their effectiveness in characterizing these impacts. The methods reviewed are divided into two categories: (1) screening-level analyses for establishing policy and regulatory priorities, and (2) specific methods for evaluating potential impacts based on a comparison of environmental concentrations of contaminants to ecological benchmarks (Exhibit 15). The methodological approaches used in each category are described and evaluated in Sections 5.1 and 5.2. A general discussion of methods used in policy and regulatory studies is presented in Section 5.3.

A second type of screening-level analysis, used in the Superfund program, is not included in this review. The Superfund program uses the Hazard Ranking System (HRS) as a screening-level device for establishing remedial priorities at hazardous waste sites. The HRS score is used to determine whether a site is placed on the National Priorities List (NPL) and thus eligible for Superfund-financed remediation. The HRS is a scoring system that evaluates factors (e.g., toxicity of substances, number and type of potential receptors) that are indicators of the risks to human health or the environment associated with a given site. Both the current HRS and the proposed revisions to the HRS (53 Fed. Reg. 51962, December 23, 1988) consider ecological risks to a specified list of "sensitive environments", but in both models human health risks are weighted more heavily than ecological risks. Under the current HRS, a site cannot be included on the NPL solely on the basis of ecological concerns, although such concerns can contribute to NPL inclusion. The final form of the revised HRS will not be available until early 1990. Although it will expand consideration of ecological concerns, the extent to which this will affect NPL inclusion cannot be determined at present.

An evaluation of the HRS was beyond the scope of this project for two reasons. First, our review of Superfund sites was limited to those already on the NPL, so all sites already had passed through the screening process before being identified for this study. Second, EPA's Office of Emergency and Remedial Response currently is sponsoring a comprehensive review and evaluation of the proposed revisions to the HRS, and thus it was unnecessary to attempt to duplicate such an effort.

5.1 Screening-Level Analyses for Establishing Policy and Regulatory Priorities

The purpose of these screening-level analyses is to provide a broad overview of the overall nature and extent of ecological impacts associated with diverse problem areas or different types of facilities, wastes, or waste management practices. Four general types of screening-level analyses were used: (1) proximity analyses, (2) surveys of damage case studies,

EXHIBIT 15

APPROACHES USED TO CHARACTERIZE ECOLOGICAL IMPACTS IN POLICY AND REGULATORY STUDIES

Screening-Level Analyses	Specific Methods
Proximity Analyses	Hazard Index for Multiple Contaminants
Survey of Damage Case Studies	Ecosystem Exposure-Response Model
Quantitative Modeling Based on Damage Case Studies	
Comparative Risk Estimation	

(3) quantitative modeling of potential impacts based on damage case scenarios, and (4) comparative risk estimation. The procedural steps used in each approach are summarized in Exhibit 16. Each approach is described and evaluated in a separate section below.

5.1.1 Proximity of Waste Sites to Sensitive Environments

Description Evaluation of the proximity of waste sites to sensitive environments was used in the Oil and Gas Report to Congress (EPA/OSW 1987b), the Coal Utilities Report to Congress (EPA/OSWER 1988), and the Mining Wastes Report to Congress (EPA/OSWER 1985). The basic procedure is to determine how many waste sites are located within or in close proximity to sensitive or valued environments. The term sensitive environment refers to many types of environmental areas that are either ecologically critical, unique, or vulnerable; are of particular cultural or historical significance; or have been set aside for the purpose of conservation. Categories of sensitive environments include endangered and threatened species habitats, wetlands, National Forests, and National Parks. Locations of these environments are identified from the U.S. Fish and Wildlife Service, the Nature Conservancy National Heritage Program, and U.S. Geological Survey quadrangle maps. A predetermined radius is used to define "close proximity". For example, in the Coal Utilities Report to Congress, all sensitive environments within a 5-km radius of coal combustion waste sites were identified.

Evaluation The basic assumptions inherent in this approach are that impacts to sensitive environments are of greater concern to society than are comparable impacts to other environmental areas. Hence, waste sources located near or in sensitive environments have a greater potential for environmental impact than do those that are not located in or near such environments. Although the proximity of waste sources to sensitive environments is not an explicit criterion for determining the potential for ecological impacts, it is an effective screening-level tool that provides a preliminary assessment of potential impacts. This approach does not attempt to provide information on the general types of impacts possible or the likelihood of such impacts. It also does not attempt to provide information useful for site-specific decisions.

5.1.2 Survey of Damage Case Studies

Description The purpose of damage case surveys is to characterize and identify the nature of actual impacts associated with the types of activities under review and identify the major factors (e.g., waste types, disposal technologies, environmental settings) that are associated with such damages. This approach was used in the Oil and Gas Report to Congress (EPA/OSW 1987b) and the Smelting and Refining Report to Congress (EPA/OSW 1988b). The initial steps are to identify specific facilities where damages have been noted (usually by contacting various personnel in Federal, Regional, and State agencies responsible for monitoring such facilities), collect and review documentation for these facilities, and summarize the information contained in these documents (Exhibit 16). For example, information contained in the Oil and Gas damage case summaries included the date, location, type, and volume of wastes released, whether the release involved a violation of state

EXHIBIT 16

PROCEDURAL STEPS USED IN SCREENING-LEVEL APPROACHES IN POLICY AND REGULATORY STUDIES

Proximity Analyses	Survey of Damage Cases	Quantitative Modeling	Comparative Risk Estimation
Select sample of sites for analysis	Identify damage cases and gather documentation	Identify damage cases and gather documentation	Define problem areas, ecological stressors, and ecosystems
Define "sensitive" environments	Identify major factors associated with ecological damages	Identify major factors associated with ecological damages	Evaluate ecological risks for each problem area/stressor/ecosystem combination
Define proximity radius	Combine factors into "typical" scenarios	Combine factors into "typical" scenarios	Aggregate risk estimates across problem area/stressor/ecosystem combinations
Evaluate proximity of sites to environments	Evaluate actual impacts from "typical" scenarios	Model contaminant releases from "typical" facilities	Derive final ranking for problem areas by consensus
	Evaluate potential impacts from "typical" scenarios		

regulations, the type of waste management technology involved, and the nature and extent of the resultant damage. The various damage case descriptions then are combined into one or more "typical" damage case scenarios according to geographic area and specific affected media, waste types, and waste management practices.

Evaluation A survey of damage case studies provides a broad overview of the nature of ecological impacts observed and the types of contaminant and waste management scenarios responsible for those impacts. It also identifies areas for additional detailed investigation. Because it is focused on a nationwide perspective, this approach does not attempt to provide information that is useful for site-specific decisions. The description of ecological impacts also is largely qualitative because information usually is not collected from all areas nationwide, the sites selected are not a representative sample of sites, and the information evaluated is limited to that contained in the available documentation. Thus, it is difficult to determine how well the "typical" damage case scenarios identified in the review are representative of actual conditions nationwide.

5.1.3 Quantitative Modeling of Potential Impacts Based on Damage Case Scenarios

Description Quantitative modeling of potential impacts was used in the Mining Wastes Report to Congress (EPA/OSWER 1985) and the Oil and Gas Report to Congress (EPA/OSW 1987b). This approach builds upon the analysis of damage case scenarios discussed in the above section. In the Oil and Gas Report to Congress, damage case scenarios were used to construct "typical" model scenarios to represent the major combinations of waste types, waste management techniques, and environmental settings for each geographical region of the U.S. Only one scenario involved an estimation of potential ecological impacts. This was the direct discharge of produced waters or drilling pit wastes from stripper oil wells[6] to surface waters. In the Smelting and Refining Report to Congress, concentrations of eight constituents in 17 representative waste streams were estimated in receiving surface waters based on ground water discharge and surface runoff. In both studies, modeled concentrations of constituents in the receiving waters were compared to AWQC to determine whether ecological benchmark levels would be exceeded. Hence, the estimate of potential impacts was based on population-level ecological endpoints.

Evaluation This approach provides an additional screening-level analysis of the potential for ecological impacts for certain types of production facilities. Because AWQC were used, this approach assumed that populations were valid surrogates for ecosystem-level impacts. Because this type of modeling is based on "typical" scenarios and facilities, the approach does not attempt to provide information useful for site-specific decisions. Scenarios modeled for the Oil and Gas Report to Congress were based partially on risks to human health, so very few waste constituents were selected on the basis of ecological toxicity, and some potential ecological exposure pathways were not considered.

---

[6] Stripper oil wells are low-level production wells that generate relatively small waste volumes.

5.1.4 Comparative Risk Estimation

Description Comparative risk estimation is a method used to rank the relative ecological impacts associated with diverse problem areas for the purpose of establishing policy and regulatory priorities. Risk estimation has been conducted only on those problem areas and their components for which EPA has statutory authority. Three comparative risk estimates were conducted recently: the OSWER Comparative Risk Project (EPA/OSW 1988a), the National Comparative Risk Project (EPA/OPA/OPPE 1987), and the Regional and State Comparative Risk Project (ICF 1987). The OSWER Comparative Risk Project focused exclusively on 24 OSWER problem areas (e.g., municipal landfills, PCB wastes, exempt underground storage tanks). The National and the Regional and State Comparative Risk Projects focused on a broader range of problem areas (e.g., criteria air pollutants, acid deposition, stratospheric ozone depletion), some of which also are OSWER problem areas (e.g., active hazardous waste sites, inactive hazardous waste sites, municipal waste sites, underground storage tanks). In each project, separate workgroups evaluated and ranked each problem area according to its relative impacts to health, welfare, and the environment. These separate rankings then were combined to obtain the overall priority ranking of each problem area. In this review, we focused only on the methods used to evaluate ecological impacts.

Although the specific methods differed among the three comparative risk projects, certain steps were common to all (Exhibit 16). These included: defining problem areas, ecological stressors[7], and ecosystems of concern, estimating ecological risks for each problem area/stressor/ecosystem combination, aggregating the risk estimate across problem area/stressor/ecosystem combinations, and deriving a final consensus ranking for each problem area. Dividing the evaluation into problem area/stressor/ecosystem combinations is necessary because different numbers and types of stressors are associated with each problem area, and the ecological impacts associated with a given stressor depend to a large part on the type of ecosystem exposed to the stressor. As many as 24 different stressors and 16 types of ecosystems were identified in these projects. The risk estimate for each problem area/stressor/ecosystem combination generally was based on exposure potential (including the areal extent of exposure), hazard potential (including reversibility of impacts), and modifying factors such as uncertainty, trend, and existing controls in place. Scoring methods, aggregation procedures, and the final consensus ranking process were semi-quantitative and relied considerably on professional judgment. Specific methodological approaches used in each project are described below.

---

[7] Ecological stressors are constituents or activities that adversely affect ecosystems and their biotic components. These include toxic constituents (e.g., metals, organic chemicals), conventional pollutants (e.g., B.O.D., nutrients, sediments), and physical activities (e.g., road construction, habitat destruction).

In the OSWER Comparative Risk Project, the ecological workgroup characterized both actual and potential impacts associated with each problem area semi-qualitatively based on available data and professional judgment. For each problem area, information was compiled for a number of data elements, and each was scored from 1 to 5. These data elements were grouped into four data composites: (1) number of sources and releases, (2) concentration of contaminants to which receptors were exposed, (3) number, size, and uniqueness of receptors exposed, and (4) the toxicity of constituents to receptors. The final ranking was derived from the four data composite scores. Stressors considered were limited to toxic constituents; ecosystems were defined in the receptor and toxicity data composites.

In the National and Regional and State Comparative Risk Projects, the hazard potential of each stressor on each ecosystem was evaluated and given a qualitative or numeric score. Severity of impacts included the intensity of effects caused by the stressor, biotic level(s) of organization affected, and reversibility of impacts. Levels of exposure of each ecosystem to each stressor also were determined. Exposure levels were measured directly, modeled, or estimated from the magnitude or pattern of major releases of the stressor. An important component of exposure was the areal extent of the ecosystem exposed. Finally, the scores were combined across stressors and ecosystems to derive a relative risk ranking for each problem area. Both projects attempted to evaluate actual and potential impacts given patterns of exposure and severity of impacts associated with such exposures.

Evaluation Comparative risk estimation provides a broad overview of the relative ecological hazards and/or impacts associated with each problem area being analyzed. Because its purpose is to identify which problem areas pose the greatest ecological threats, this approach does not attempt to provide new information on ecological impacts or information that is useful for site-specific decisions. Instead, it relies largely on data from existing studies to estimate impacts or risks. Moreover, considerable professional judgment is required to estimate risks or impacts from problem areas for which few data are available. Because the risk estimates are largely qualitative, problem areas can be grouped into general categories of relative risk, but specific ordering within each general category is not possible. The ecological assumptions inherent in the approach depend on the methods and techniques used to provide the data upon which the risk evaluation is based.

5.2 Specific Methods for Evaluating Potential Ecological Impacts

Several specific methods for evaluating potential ecological impacts based on a comparison of environmental concentrations of contaminants to ecological benchmarks have been used in regulatory and policy studies. This general approach has been described and evaluated in Chapter 4. Two specific methods are reviewed here (Exhibit 15): the hazard index approach for multiple contaminants used in the analysis of hazardous waste tank systems (EPA/OSW 1987a), and the ecosystem exposure-response model developed for the RCRA Risk-Cost Analysis Model (EPA/OSW 1984). Each is described and evaluated in a separate section below.

5.2.1 Hazard Index for Multiple Contaminants

Description The purpose of a hazard index is to provide a standardized methodology for determining ecological risks posed by the release of contaminant mixtures. The approach reviewed here was used to evaluate environmental risks posed by the release of contaminants from hazardous waste tanks. The hazard index is based on the work of Barnthouse et al. (1986) and the Office of Pesticide Programs (EPA/OPP 1986). A quotient method is used in which measured or modeled environmental concentrations (EC) of each contaminant are compared to its ecological benchmark (B). The benchmarks are AWQC or LOELs or NOELs divided by safety factors. The quotients for individual chemicals are summed to derive a hazard index, and the hazard index is compared to predetermined concern levels[8] to determine the likelihood of ecological impacts. If the hazard index is less than or equal to 1.0, a low probability of ecological impacts is assumed. A hazard index between 1.0 and 10.0 is assumed to indicate possible ecological impacts. A hazard index greater than or equal to 10.0 is assumed to indicate probable ecological impacts.

Both aquatic and terrestrial receptors are considered, and endpoints are focused at the population level. Toxicity values are based on indicator species which most closely resemble the sensitivity of potential site-specific receptors. For aquatic species, the ecological benchmark for a given chemical is set equal to EPA's chronic AWQC. If a chronic AWQC is not available, a chronic LOEL divided by 10, or an acute LOEL divided by 100 (whichever is lower) is used. For terrestrial species, the ecological benchmark for a given chemical is set equal to the lowest acute NOEL divided by 100 or the lowest chronic NOEL divided by 10. An additional safety factor of 10 is used when evaluating potential impacts to endangered or threatened species.

Evaluation Dose additivity is based on the assumption that the components of the mixture have the same mode of action and elicit the same effect. This approach also assumes equivalent slopes of dose-response curves, although thresholds can differ. As a result, potential antagonistic, synergistic, or potentiating interactions are not considered. Because only endpoints at the population level are considered, the approach also assumes that populations are valid surrogates for community- or ecosystem-level effects. If impacts to endangered species are being evaluated, however, this additional assumption does not apply. Within the limits of its assumptions, this approach provides a quantitative estimate of the likelihood of adverse ecological effects resulting from multiple contaminants at a site. In principle, it also can be used to derive site-specific cleanup criteria, although to our knowledge it has not been used for this purpose. The approach does not consider certain exposure pathways (e.g., food chains), it has not been validated, and it does not quantify uncertainty.

---

[8] This approach assumes additivity of effect (i.e., the same mode of action for different chemicals). Levels of concern are the same levels of concern that would be used for single-chemical quotient estimation of impact.

5.2.2 Ecosystem Exposure-Response Model

Description The ecosystem exposure-response model was developed for the RCRA Risk-Cost Analysis Model (EPA/OSW 1984). The purpose of this approach is to provide a consistent method for analyzing the relative risks and costs of different RCRA waste management practices. The model also includes modules to assess risks to human health, but these are not reviewed here. The basic approach is to compare environmental concentrations of contaminants to an empirically-derived ecosystem exposure-response curve rather than a simple threshold benchmark. Risks are calculated on a relative scale rather than an absolute scale.

Risks to both terrestrial and aquatic organisms are assessed, but the environmental setting for a given site is defined almost exclusively in terms of surface water (i.e., lakes, rivers, marshes, and coastal areas). The risk assessment is based on the most toxic constituent present. Toxicity is assessed by constructing an ecosystem exposure-response curve such that the ecosystem threshold is equal to the threshold concentration for the most sensitive species, and the range of concentrations between the threshold and a "catastrophic" level is 2.5 orders of magnitude higher. The model's ecosystem damage function varies between 0 (no impact) when the concentration of the constituent is at or below threshold and 1.0 (100% impact) at pollutant concentrations 2.5 or more orders of magnitude greater than threshold. This range of effects is based on four case studies where minimal to catastrophic impacts were observed.

Empirical safety factors, based on data quality and completeness, exposure duration, and the absence of an experimental threshold, are used to address uncertainty in deriving the ecosystem threshold value. For chemicals that bioconcentrate extensively, the ecosystem threshold is assumed to be five orders of magnitude below the catastrophic concentration. Surface water concentrations are estimated downgradient from the point of release with a simple steady-state model based on the flow rate of the water body, release rate of the chemical, and overall decay rates. Risk is determined by the point at which this concentration falls on the ecosystem exposure-response curve.

Evaluation This approach provides a quantitative estimate of the severity of impacts to the ecosystem above threshold levels. Because the ecosystem exposure-response curve is derived empirically, the assumption is that the data from which it is derived are representative of most substances and ecosystems, which is unlikely to be the case. This approach does not evaluate impacts due to multiple contaminants. In principle, the approach can be used to quantify the areal extent of impacts at a given risk level. However, the ecosystem-exposure response relationships are based on an extremely limited data base and have not been validated. Moreover, no particular "acceptable" impact level has been identified.

5.3 General Evaluation of Methods Used in Regulatory and Policy Studies

In the previous sections, four screening-level approaches used in policy and regulatory studies were identified. These were: evaluation of the proximity of waste sites to sensitive environments, survey of damage case studies, quantitative modeling of potential impacts, and comparative risk estimation. Two specific methodologies also were identified: the hazard index for multiple contaminants, and the ecosystem exposure-response model. In this section, these approaches are discussed according to the level of effort required and the types of information provided by that level of effort (Exhibit 17).

Evaluating the proximity of waste sites to sensitive environments provides information on the number and types of waste sites that are found in close proximity to environments that have particular societal or economic value. This relatively low-effort screening approach does not provide information on the general types of impacts that might occur to these environments or the likelihood that they will occur. However, if there is very little geographic overlap between waste sites and sensitive environments, it is unlikely that adverse impacts to those environments will occur.

Surveys of damage case studies provide information on the nature of actual impacts associated with the types of activities under review. Such surveys also identify the major factors (e.g., waste types, disposal technologies, environmental settings) that are associated with such damages and areas for additional detailed investigation. Although the information on ecological impacts is based on particular site-specific conditions, this information is combined into generalized scenarios for analysis. Hence, analyses are largely qualitative and are not intended to provide information useful for site-specific decisions. Moreover, the completeness of the analysis depends entirely on how adequately documentation can be obtained. This approach can identify the types facilities or practices that are not located near sensitive environments but are causing adverse impacts to non-sensitive environments.

Quantitative modeling of potential impacts based on damage case surveys provides information on the potential impacts associated with the types of activities and major factors associated with observed damages. Although the modeling also is based on "typical" facilities and scenarios, it can identify potential impacts that have not been observed in the past. Hence, it can identify particular types of facilities or waste management practices that might pose risks to ecological receptors, even if no adverse impacts actually have been associated with such facilities.

Comparative risk estimation provides a broad overview of the relative ecological hazards and/or impacts associated with each problem area being analyzed. Because it is not limited strictly by data availability, it can identify particular problem areas that have a high potential for ecological damage about which there is little documentation of actual impacts (e.g., ozone depletion). It also can identify problem areas for which there is a great deal of documentation but a relatively small potential for ecological damage. There are several different approaches to this process. The ranking procedure can be based entirely on potential impacts, potential impacts and likelihood of exposure, and/or actual impacts resulting from known levels of exposure. Information on known impacts provides a more precise evaluation of the current extent of ecological problems, while information on potential

EXHIBIT 17

EVALUATION OF APPROACHES USED TO CHARACTERIZE ECOLOGICAL IMPACTS IN POLICY AND REGULATORY STUDIES

Approach/Technique	Information Provided	Information Not Provided	Information Gained
Screening-Level Analyses			
Proximity of Waste Sites to Sensitive Environments	Number of sites located in or in close proximity to sensitive environments	Types of impacts possible Likelihood of impacts	Screening-level identification of types of sites with potential for ecological impacts
Survey of Damage Case Studies	Types of impacts associated with activities under review Contaminants and settings associated with impacts	Estimate of the extent of actual impacts associated with activities under review	Identification of types of facilities and settings that have resulted in the greatest amount of ecological damage in the past or at present
Quantitative Modeling Based on Damage Case Studies	Potential impacts associated with activities under review Types of contaminants and releases associated with potential impacts	Estimate of the extent of potential ecological impacts associated with activities under review	Identification of types of facilities that pose the greatest potential for ecological impacts
Comparative Risk Estimation	Estimate of relative ecological risks/impacts associated with problem area under review	New information about ecological impacts Quantitative estimates of ecological risks	Identification of problem areas that pose the greatest (and least) ecological risks

EXHIBIT 17 (continued)

EVALUATION OF APPROACHES USED TO CHARACTERIZE ECOLOGICAL IMPACTS IN POLICY AND REGULATORY STUDIES

Approach/Technique	Information Provided	Information Not Provided	Information Gained
Specific Methodologies			
Hazard Index for Multiple Contaminants	Estimate of the likelihood of population-level impacts from the additive effects of multiple contaminants	Estimate of the likelihood of population-level impacts from synergistic, antagonistic, or potentiating effects	Cleanup criteria for mixtures of contaminants[a]
Ecosystem Exposure-Response Model	Quantitative estimate of the likelihood of ecosystem-level impacts from single contaminants	Estimate of the likelihood of ecosystem-level impacts from multiple contaminants	Cleanup criteria for single contaminants based on ecosystem-level impacts[a]

---

[a] Method was not used for this purpose in documents reviewed.

impacts provides a more precise evaluation of the extent of potential ecological problems.

The hazard index for multiple contaminants and the ecosystem exposure-response model are relatively low-effort methods because they utilize readily-available chemical-specific data. The hazard index provides an estimate of the relative likelihood of population-level impacts from the additive effects of multiple contaminants. Use of this index could identify potential ecological impacts at sites at which each contaminant singly was below its respective benchmark. The ecosystem exposure-response model provides a quantitative estimate of the relative likelihood of ecosystem-level impacts from single contaminants. Both methods could be used to establish cleanup criteria at specific sites. The basic limitation in using these methods is that neither has been validated adequately.

CHAPTER 6

OPPORTUNITIES FOR ADDITIONAL METHODS DEVELOPMENT

In this chapter, we outline several ways in which additional methods development could make ecological assessments at OSWER sites more comprehensive and standardized. These suggestions are presented in a risk assessment context; methods development opportunities are categorized according to exposure (Section 6.1), hazard (Section 6.2), exposure-response (Section 6.3), and risk characterization (Section 6.4). Although these methods opportunities are important from an overall OSWER perspective, the importance of specific methods development opportunities for selected OSWER programs or activities might differ (see Chapter 7).

The suggestions outlined below could be implemented through specific policy statements, guidance documents outlining the general elements to be considered in an ecological assessment, or formalized assessment procedures. Many of these suggestions also could be implemented by expanding the role of Regional bioassessment groups[9] in the CERCLA site-specific review process and incorporating such groups into the RCRA site-specific review process. Bioassessment groups have been very effective in providing guidance for sampling protocols, data analysis and interpretation, use of toxicity data, and other specific suggestions outlined below. These groups also have been extremely effective in providing guidance in selecting the appropriate level of effort for a given site. One efficient way to implement the suggestions outlined below might be to provide formalized guidance for specific approaches and techniques and rely on bioassessment groups to provide guidance on selecting the specific approaches and techniques that are most appropriate for a given site.

Increased communication among OSWER programs, EPA offices, other state and federal agencies (e.g., NOAA, Fish and Wildlife Service) is an essential element in any effort to develop a systematic and comprehensive ecological assessment methodology. Regular exchange of information about new techniques, new guidelines, and new applications of existing techniques among Regional and Headquarters personnel would facilitate the rapid adoption and standardization of practical methods nationwide. Implementation of most of the suggestions outlined below also would be facilitated by a coordinated effort from several offices and agencies. For example, increasing the toxicity data base for terrestrial organisms could be facilitated if OSWER published a list of substances and species for which data were required, the U.S. Fish and Wildlife service devoted some toxicity testing resources to those substances, and/or EPA sponsored efforts to develop guidelines for using laboratory mammals and agricultural crops as surrogates for wild plants and animals.

---

[9] Regional bioassessment groups include representatives from Superfund and the two agencies designated as national resource trustees: the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service. These groups review, evaluate, and amend proposed ecological assessment protocols at Superfund NPL sites.

6.1 Characterizing Exposure

6.1.1 Standardizing Exposure and Intake Assumptions

There was considerable variation among OSWER sites reviewed in the exposure and intake assumptions used to evaluate exposure potential. For most types of organisms, information required to develop such assumptions generally is available in the open literature for most types of organisms, although considerable effort is required to extract such data. Ecological assessments at OSWER sites could be more systematic if a common set of exposure and intake assumptions were developed for each type of indicator organism. Such assumptions might include metabolic rate, body mass and volume, lipid content and turnover, diet, daily food and water intake, longevity, age to maturity, and position in trophic web. As a starting point, a common set of assumptions could be developed for those organisms selected as organisms of concern for given ecosystems (see Section 6.4.1).

6.2 Characterizing Hazard

6.2.1 Characterizing Hazards from Single and Multiple Contaminants

There was considerable variability among OSWER sites in how the degree to which contaminant concentrations exceeded benchmark levels was used in characterizing hazard (see Section 4.2). One way in which to standardize ecological hazard characterizations at OSWER sites would be to develop a uniform quotient method establishing levels of concern for single chemicals and a uniform hazard index establishing levels of concern for multiple chemicals based on a comparison of the environmental concentration (EC) with the benchmark (B). In the RCRA program, a hazard index based on work by Barnthouse et al. (1986) and the Office of Pesticide Programs (EPA/OPP 1986) was used to establish levels of concern for the release of multiple-contaminant waste streams from hazardous waste tanks (see Section 5.2.1). If this and/or some other hazard indices were adopted by OSWER on a program-wide basis, these indices could serve as the basis for a uniform method for evaluating hazard from multiple contaminants.

6.2.2 Guidance in Using Media Toxicity Tests

Media toxicity tests were used at a number of OSWER sites to determine whether mixtures of contaminants in soils, leachate, sediments, and the water column are potentially toxic to site-specific aquatic or terrestrial organisms. Several standard toxicity test protocols exist, and others are under development by EPA's laboratories. However, in none of the site-specific documents reviewed was there a clear statement defining a "significant" ecological hazard based on a media toxicity test result (see Section 4.1.3). Characterizing ecological hazard based on media toxicity tests could be standardized by (1) summarizing the types of media toxicity tests available, the species to which they can be applied, the endpoints they measure, and the ecological significance of changes in those endpoints, and (2) developing guidance for using toxicity test results to determine ecological benchmark levels, and denoting levels of concern for each toxicity test. Such guidance was developed recently for the NPDES permitting process (EPA/OW 1985, 1987) and could be adopted directly by OSWER to establish levels of concern and cleanup criteria for some ecosystems.

6.2.3 Data Needs

Three main data needs currently are limiting the extent to which ecological hazards can be characterized comprehensively and systematically at OSWER sites. The first is threshold toxicity data for terrestrial and aquatic organisms. Although acute and chronic toxicity data are available for more chemicals and species in aquatic ecosystems than in any other type of ecosystem, additional data are needed. In the near term, methods to predict toxicity levels from chemical structure-activity relationships might be used to provide advisory benchmark levels for additional substances. In the long term, toxicity testing concentrated on substances found most frequently at high concentrations at OSWER sites would provide a toxicity data base of particular utility to OSWER.

The second major data need is information on the relationship between tissue residue levels and adverse effects in biota. Elevated tissue residue levels generally can be used only to determine whether biota have been exposed to contaminants. The third major data need is the effect of chemical mixtures on aquatic and terrestrial biota. In the near future, this need probably can be filled only by using media toxicity tests to determine the potential ecological impacts from site-specific mixtures.

6.3 Characterizing Exposure-Response

6.3.1 Derivation of Ecological Benchmarks

Ecological benchmarks are critical in establishing levels for limiting concentrations or releases of substances in the CERCLA remedial process and in RCRA programs such as permitting, delisting, and corrective action. There was considerable variability among the OSWER sites reviewed in selecting contaminants-of-concern based on the types of widely-recognized ecological benchmarks available (i.e., EPA's ambient water quality criteria) and in derivation of additional benchmarks from toxicity data (see Section 4.2).

Ambient water quality criteria are available for a limited number of substances found frequently at high concentrations at CERCLA and RCRA sites (ICF 1988a), and they generally apply only to aquatic organisms. Although toxicity data are not available for many contaminants and organisms, existing data are not being used fully. For example, the U.S. Fish and Wildlife Service has compiled a data base of acute toxicity data for 410 chemicals and 66 species of freshwater animals (USFWS 1986), EPA's Gulf Breeze Laboratory has compiled a data base of acute toxicity data for 197 chemicals and 52 species of estuarine organisms (EPA 1987), and other toxicity values are available in the open literature and through on-line data bases. There also are considerable toxicity data for laboratory mammals and agricultural crops, but no guidelines exist for using such data to develop benchmarks for wild plants and animals.

Analysis of the relatively extensive toxicity data base for aquatic organisms also has enabled the derivation of models for determining safety factors applicable to acute and/or chronic toxicity data to adjust for acute-to-chronic toxicity ratios and/or differences in species sensitivity (e.g., Suter et al. 1983, EPA/OTS 1984). Methods to predict toxicity levels for additional chemicals from chemical structure-activity relationships also are under development by EPA's Office of Water and the Duluth laboratory. EPA's Office of Water also has proposed a methodology for deriving ambient water quality advisories[10] from more limited toxicity data. This methodology is scheduled to be released for public comment in early 1989 and finalized by mid-1989. These methods might be used to provide benchmark levels for additional substances.

6.3.2 Wider Use of Existing Techniques and Approaches

Many promising, cost-effective techniques such as histopathology and necropsy were used at only a small proportion of the OSWER sites reviewed (see Section 3.1.2). Use of such techniques on a more widespread and systematic basis could be encouraged by (1) summarizing the types of techniques available, the species to which they can be applied, the endpoints they measure, and the ecological significance of changes in those endpoints, (2) developing guidance for using such techniques, and (3) collecting and disseminating information on the way in which particular techniques and approaches were used to characterize impacts at specific sites.

6.3.3 Exposure-Response Data

One data need currently is limiting the extent to which ecological risks can be characterized comprehensively and systematically at OSWER sites. This is exposure-response data for terrestrial and aquatic organisms. Most toxicity data in the literature are presented as acute toxicity levels (e.g., LC_{50}s, LD_{50}s, or EC_{50}s or chronic LOELS or NOELS). It is difficult to predict effects above threshold levels with data of this nature.

6.4 Characterizing Risk

6.4.1 Receptor Characterization

One key element limiting the standardization of ecological assessments is a lack of consensus on which ecological receptors should be used to characterize ecological impacts. Elements of receptor characterization include biotic level of organization, taxonomic group of organism, and specific ecological endpoint used (see Sections 3.1 and 4.1). There was a great deal of variability among OSWER sites in how receptors were characterized (see Sections 3.2 and 4.2). Some of this variability could be reduced by delineating a standard set of organisms and ecological endpoints that would serve as surrogates for particular ecosystems of concern. Such a set need not be comprehensive at first; delineation of a minimum set would provide a starting point that could be amended in the future. For example, a starting list of organisms might include commercially important organisms (e.g., fish, shellfish, game animals) and endangered species. Organisms might be identified generically (e.g., microtine rodents, vermivorous birds) rather than specifically. Additional organisms and endpoints could be added on a site-specific basis. Guidance in selecting organisms most relevant for a given site could be developed. Elements of such guidance might include relative likelihood of exposure, sensitivity to site-specific contaminants, ability to bioaccumulate, and position in the food chain. A standard set of organisms and endpoints also might assist efforts to develop additional ecological benchmarks (see Section 6.3).

---

[10] These advisories are benchmarks designed to protect aquatic ecosystems in the same manner as do ambient water quality criteria but are based on more limited toxicity data (see ICF 1988c).

6.4.2 Determining Areal Extent and Reversibility of Impacts

An estimate of the areal extent or reversibility of ecological impacts rarely was included in ecological assessments at OSWER sites (see Sections 3.2 and 4.2). As a result, no distinction was made between a situation in which the majority of a given type of ecosystem in an area is affected or threatened and one in which only a very small proportion of an ecosystem is potentially affected. Such information is particularly important when community-level endpoints are used to characterize risks. For example, a small change in a community diversity measure over a widespread area might be more ecologically significant than a large change over a very restricted area. Guidance in characterizing and interpreting areal extent and reversibility of impacts would make ecological assessments more systematic at OSWER sites.

6.4.3 Determining the Ecological Significance of Impacts

At no OSWER site reviewed was there a clear statement as to what was considered a "significant" ecological impact based on evaluations of community structure and other characterizations of actual ecological impacts (see Section 3.1). There appeared to be considerable uncertainty about the natural range in variation in most ecosystem-, community-, and population-level endpoints used at these OSWER sites and hence what should be considered an ecologically significant change. This uncertainty could be reduced by efforts to compile information on the natural range of variation in these endpoints, both on a short-term (e.g., diel) and long-term (e.g., seasonal) basis, and in establishing levels of concern based on the magnitude of change in these endpoints. The Ohio Environmental Protection Agency (Ohio EPA 1988) recently developed water quality standards based on measures of community structure. These standards incorporate levels of concern for changes in community diversity indices based on natural community diversity in unpolluted ecosystems. Once levels of concern have been established for a given type of ecosystem, characterizing level of impact based on community structure measures is cost-effective when compared to media contaminant sampling and analysis. Such a methodology could be adopted by OSWER, although a significant investment in resources would be required to establish levels of concern for aquatic ecosystems nationwide.

6.4.4 Quantitative Ecological Risk Assessment Methodology

Currently there is no widely-accepted method for quantifying ecological risks at OSWER sites. Current approaches are limited primarily to comparing observed contaminant levels in media or biota with ecological benchmark values and/or a qualitative or semi-quantitative evaluation of the likelihood of adverse effects in various biota resulting from various exposure scenarios. These approaches do not provide information on the relative severity of effects at concentrations above the threshold values, or the potential effects of exposures to multiple contaminants.

Components of a methodology to quantify ecological risks might include (1) selection of appropriate constituents of concern and ecosystem- and species-level endpoints, (2) evaluation of threshold effects and exposure-response relationships in these endpoints, (3) selection of appropriate locations for measuring exposure potential and an evaluation of exposure potential at these locations (including potential for bioaccumulation and food-chain exposure), (4) evaluation of the areal extent or proportion of the ecosystem affected, and (5) evaluation of the reversibility of adverse effects.

In the near future, it will be difficult to develop a comprehensive, quantitative risk assessment methodology because there is little scientific consensus on appropriate receptors, endpoints, exposure assumptions, and exposure-response relationships, and it is difficult to generalize results from one ecosystem or species to another. However, some quantitative methods are being developed by EPA's Office of Research and Development.

CHAPTER 7

GENERAL IMPLICATIONS FOR OSWER AND SPECIFIC METHODS DEVELOPMENT OPPORTUNITIES FOR SELECTED OSWER PROGRAMS AND ACTIVITIES

In this chapter, we briefly discuss the general implications of this review and analysis for OSWER. For several selected OSWER programs and activities, we also identify specific methods needs, how existing methods are or could be used to meet these needs, and which specific methods development opportunities are most important. Specific RCRA programs include regulatory development, hazardous waste definition and determination, Subtitle C permitting, and Subparts F and S corrective action. Specific CERCLA programs and activities include the removal program, pre-remedial activities, selection of remedy, and implementation and completion of remedy. General implications are discussed in Section 7.1, and specific program needs and opportunities are identified in Section 7.2.

7.1 General Implications for OSWER

There was considerable variability among OSWER sites reviewed in the type and number of approaches and techniques used in ecological assessments, the sampling intensity and level of effort devoted to such assessments, and the manner in which particular approaches (e.g., use of toxicity data and ambient water quality criteria to establish benchmarks) were applied at a given site (see Sections 3.2 and 4.2). Some of this variability resulted from differences among sites in the need for ecological assessment and in the types of ecosystems being assessed. Some might have resulted from resource and personnel constraints. However, the general lack of policy and guidance for conducting ecological assessments apparently has resulted in the development of numerous independent approaches in methods, level of effort, and resources devoted to such assessments.

Currently there is no OSWER policy or guidance for selecting for a particular site the appropriate receptors and ecological endpoints of concern; background values and/or reference sampling locations; approaches, techniques, and level of effort; and contaminants of concern. There also is no OSWER policy or guidance for use of existing toxicity data, interpretation of survey and toxicity test results, and presentation and discussion of results in site-specific documents. The absence of policy or guidance in many cases is due to a lack of appropriate scientific knowledge and data, and additional fundamental research addressing these data gaps clearly is needed. Policy decisions that could be reached given current knowledge and data were identified in Chapter 6 and are discussed for selected OSWER programs and activities in this chapter. In the absence of clear policy and guidance, evaluations of ecological impacts at OSWER sites will continue to be highly variable in scope and quality.

Without clear policy guidelines, it is not certain whether information about ecological impacts can play a significant role in risk management decisions or the extent to which it should do so. The limited ecological input to remediation and control goals (see EPA/OPA 1989b) suggests that current approaches, as applied, provide information that is not widely used in risk management decisions. If a decision is reached to use ecological impacts information in risk management decisions, additional guidance in conducting ecological assessments will be required. Without additional policy and guidance, the information provided by these approaches probably will continue to play only a limited and inconsistent role in risk management decisions.

If a decision is reached to include information on ecological impacts in risk management decisions at OSWER sites, moderate investment of resources in developing guidance, modifying and standardizing current approaches, and further development of promising techniques and methods will result in a more systematic and comprehensive approach to ecological assessments. Several suggestions for such developments were outlined in Chapter 6. If developments proceed along any of these lines, there will be additional implications for current OSWER and EPA programs. For example, the Office of Water's ambient water quality criteria (AWQC) are the most widely-used ecological benchmarks at OSWER sites. If these or the newly-developed ambient water quality advisories (AWQA) are to be considered the only valid benchmarks for evaluating aquatic impacts, it would be useful to develop additional AWQC and AWQA for all chemicals found most commonly at high concentrations at OSWER sites.

Currently there is no widely-accepted method for quantifying ecological risks at OSWER sites, it is unlikely that such a method will be developed in the near future, and quantitative ecological risk assessment is not being conducted at many sites. For example, a quantitative risk model was used at only one of the sites reviewed for this study. Without a quantitative risk assessment method, it will not be possible to utilize information on ecological impacts in remedial, regulatory, and control decisions in the same manner in which comparable information about risks to human health is utilized. For example, while it sometimes is possible to estimate the human health consequences of various remedial alternatives (e.g., 1×10^{-6} excess cases of cancer with alternative A, 1×10^{-5} excess cases with alternative B), it will not be possible to predict the ecological consequences of various remedial alternatives with any degree of precision. Hence, if a decision is reached to include information on ecological impacts in risk management decisions, it will be necessary to rely largely on analyses of actual impacts, qualitative evaluations of potential impacts, and professional judgment.

7.2 Methods Development Opportunities for Selected OSWER Programs and Activities

In this section, we identify for selected OSWER programs and activities specific methods needs, how existing methods are being or could be used to meet these needs, and which specific methods development opportunities outlined in Chapter 6 are most important. Descriptions and evaluations of specific methods identified in this section can be found in Chapters 3, 4, and 5. To provide some context for each program, we also briefly outline the major activities of the program and the basic policy issues that need to be addressed before a standardized ecological assessment methodology can be developed. These activities and needs are described in greater detail in EPA/OPA (1989b) and ICF (1988d). The relationship between the specific methods reviewed in this report and general objectives of ecological assessment methods identified in a recent review (EPA/OPA 1988) is discussed in Section 7.2.1. Selected RCRA programs are discussed in Section 7.2.2, and selected CERCLA programs and activities are discussed in Section 7.2.3.

7.2.1 Relationship to General Objectives of Ecological Assessment Methods

EPA's Office of Policy Analysis recently sponsored a review of 20 ecological risk assessment methods developed and used by EPA and other Federal and state agencies (EPA/OPA 1988). Five general objectives of these ecological assessment methods were identified in that review and other related documents: setting standards, setting priorities, assessing damages, quantifying and managing risks, and monitoring ecological change over time. Setting standards refers to the process of establishing ambient environmental criteria, advisories, or other exposure standards (e.g., AWQC). Setting priorities refers to the process of allocating resources among programs, waste sites, or other entities on the basis of hazard, exposure potential, or other key variables driving ecological risk. Assessing damages refers to the process of evaluating the monetary cost of ecological injury. For this discussion, we will generalize this to evaluating any observed ecological impacts, whether or not the cost of those impacts is estimated. Quantifying and managing risks refers to full quantitative ecological risk assessment. Monitoring ecological change over time refers to the process of monitoring one or more ecological endpoints (e.g., community structure, toxicity of water to *Daphnia* in a toxicity test protocol) repeatedly over a period of time.

The specific objectives for which the methods reviewed in this report have been or could be used are shown in Exhibit 18. Note that OSWER is not responsible for setting standards. Specific objectives for each of the OSWER programs or activities discussed in the remainder of Section 7.2 are listed in Exhibit 19. The particular programs or activities in which the methods reviewed in this report have or could be used are shown in Exhibit 20. Important methods development opportunities for each OSWER program are listed in Exhibit 21 and discussed in Sections 7.2.2 and 7.2.3.

7.2.2 Opportunities for Methods Development in the RCRA Program

In this section, opportunities for methods development are outlined for four RCRA programs: regulatory development, hazardous waste definition and determination, Subtitle C permitting, and Subparts F and S corrective action. Each is described in a separate section below.

7.2.2.1 Regulatory Development

Background A major focus of RCRA regulatory development efforts is an evaluation of the benefits, costs, and economic impacts of proposed rulemakings and regulatory alternatives.

Policy Issues The basic policy issue in evaluating regulatory impacts is what emphasis to place on ecological impacts, particularly those that have no readily-apparent economic or societal costs.

EXHIBIT 18

RELATIONSHIP BETWEEN METHODS USED BY OSWER AND GENERAL OBJECTIVE OF ECOLOGICAL ASSESSMENT METHODS

Methods Used by OSWER	General Objective of Ecological Assessment Method			
	Setting Priorities	Assessing Damages	Quantifying & Managing Risks	Monitoring Ecological Change
Screening Characterizations				
Proximity Analyses	X			
Damage Case Surveys	X	(X)		
Quantitative Modeling	X			
Comparative Risk Estimation	X			
Characterizing Actual Impacts				
Areal Extent of Contamination		(X)		(X)
Biotic Community Structure		X	(X)	(X)
Individual Morphology/Physiology		X		X
Characterizing Potential Impacts				
Exposure Potential			X	
Quotient Method (Benchmarks)			X	
Hazard Potential (Toxicity Tests)			X	X
Quantitative Risk Modeling			X	

X currently being used for this objective
(X) might be used for this objective under certain conditions

note: OSWER is not responsible for one additional objective (i.e., setting standards)

EXHIBIT 19

RELATIONSHIP BETWEEN GENERAL OBJECTIVES OF ECOLOGICAL ASSESSMENT METHODS AND OBJECTIVES OF PARTICULAR OSWER PROGRAMS

	RCRA Programs				CERCLA Programs			
Methods Used by OSWER	Regulatory Development	Hazardous Waste Definition	Subtitle C Permitting	Corrective Action	Removal Program	Pre-Remedial Activities	Selection of Remedy	Implementation and Completion of Remedy
Setting Priorities	X	X	X	X		X		
Assessing Damages	X		X	X	X	X	X	
Quantifying and Managing Risks	X		X	X			X	
Monitoring Ecological Change			X	X			X	X

EXHIBIT 20

USE AND POTENTIAL USE OF OSWER METHODS BY OSWER PROGRAMS

Methods Used by OSWER	RCRA Programs				CERCLA Programs			
	Regulatory Development	Hazardous Waste Definition	Subtitle C Permitting	Corrective Action	Removal Program	Pre-Remedial Activities	Selection of Remedy	Implementation and Completion of Remedy
Screening Characterizations								
Proximity Analyses	X					X		
Damage Case Surveys	X	(X)						
Quantitative Modeling	X							
Comparative Risk Estimation	X							
Characterizing Actual Impacts								
Areal Extent of Contamination			X		(X)	X	X	
Biotic Community Structure			X	X		(X)	X	X
Individual Morphology/Physiology		(X)	X	X	(X)		X	X
Characterizing Potential Impacts								
Exposure Potential				X	(X)	(X)[a]	X	
Quotient Method (Benchmarks)	X	X	X	X		(X)[a]	X	X
Hazard Potential (Toxicity Test)		X	X	X			X	X
Quantitative Risk Modeling	X		X	X			X	

X has been or could be used
(X) might be used under certain conditions

[a] Proposed revisions to the HRS include evaluations of exposure and use of benchmarks.

EXHIBIT 21

METHODS DEVELOPMENT OPPORTUNITIES[a] IMPORTANT TO SELECTED OSWER PROGRAMS

Methods Used by OSWER	RCRA Programs				CERCLA Programs			
	Regulatory Development	Hazardous Waste Definition	Subtitle C Permitting	Corrective Action	Removal Program	Pre-Remedial Activities	Selection of Remedy	Implementation and Completion of Remedy
Exposure Characterization								
Exposure/Intake Assumptions			X	X			X	
Hazard Characterization								
Single vs. Multiple Contaminants			XX	XX		XX	XX	
Toxicity Test Guidance		XX	XX	XX		XX	XX	XX
Data Needs	XX	XX	XX	XX	XX	XX	XX	XX
Exposure-Response Characterization								
Ecological Benchmarks		XX	XX	XX	XX	XX	XX	XX
Wider Use of Techniques	X		X	X			X	
Exposure-Response Data	X	X	XX	XX			XX	
Risk Characterization								
Receptor Characterization			X	XX			XX	
Areal Extent, Reversibility				X			X	
Ecological Significance	XX		X	XX	XX	XX	XX	
Quantitative Risk Assessment			X	X			X	

XX most important needs
X less important needs

[a] Opportunities are described in Chapter 6.

Methods Needs The major method needs include a protocol for considering qualitative or quantitative measures of ecological impact/benefits at the national level in regulatory decision-making, and predictive methods or models that can be applied to limited data.

Available Methods Four methodological approaches are available and appropriate for ecological assessments in a regulatory development context: proximity analyses, damage case analysis, modeling of facility scenarios, and comparative risk estimation (see Chapter 5). All have been used by OSWER.

Opportunities for Methods Development Existing methodological approaches generally are adequate for qualitative or semi-quantitative ecological assessments in a regulatory development context. Guidance in applying approaches to regulatory evaluations, standardizing these approaches, and determining the ecological significance of potential impacts would lead to more complete and comprehensive incorporation of ecological impacts into evaluations. Ecological assessments in this context ultimately depend on the availability and quality of information about ecological impacts, including site-specific impacts. It thus is important for individuals conducting these types of ecological assessments to communicate specific data needs (e.g., data on the toxicity of mining wastes to terrestrial organisms) to the appropriate regulatory programs or agencies. It also is important that the regulatory programs or agencies be informed of newly-developed techniques and approaches for obtaining information about ecological impacts, particularly where existing data are scarce (Exhibit 21).

7.2.2.2 Hazardous Waste Definition and Determination

Background The major activities of the hazardous waste definition and determination program are (1) identification and listing of wastes that are hazardous to human health and/or the environment and hence subject to regulation under RCRA, and (2) delisting specific waste streams from particular generating facilities.

Policy Issues The basic policy issues include a determination of the general types of ecological impacts, if any, to consider in listing and delisting decisions, and the threshold or "significant" effect and exposure levels to define for each general type of ecological impact. Two specific policy actions would increase the importance of ecological impacts in defining and determining hazardous wastes: (1) expansion of the TC regulatory levels to include environmental effects thresholds as well as human health risk thresholds, and (2) expansion of the VHS modeling approach to consider exposures other than through the consumption of contaminated drinking water.

Methods Needs The major methods need is one or more protocols for identifying the ecological toxicity of waste stream constituents and/or mixtures.

Available Methods Two methodological approaches developed by EPA's Office of Water are available for defining hazardous wastes and determining significant effect and exposure levels. Ambient water quality criteria (AWQC) and advisories (AWQA) establish significant exposure levels for freshwater and marine life using single-constituent toxicity tests. NPDES permit protocols establish significant exposure levels for freshwater and marine life using multiple-constituent toxicity tests (media toxicity tests). To our knowledge, these methodologies have not been used in the Hazardous Waste Definition and Determination Program.

Opportunities for Methods Development Existing toxicity testing methods and protocols available from the Office of Water and other sources generally are adequate for defining and determining wastes that are hazardous to aquatic organisms. However, EPA-identified toxicity measures for aquatic organisms are available for only about half of all substances found frequently at high concentrations at CERCLA and RCRA sites, and chronic ambient water quality criteria are available for less than 15 percent of these substances (ICF 1988a). Hence, derivation of additional benchmarks for aquatic organisms is particularly important to this program (Exhibit 21). Communicating needs for additional substance-specific effect and exposure levels to the Office of Water would facilitate development of new AWQC and AWQA relevant to this program.

Existing toxicity testing methods and protocols are not adequate for determining hazards to terrestrial organisms. Definition and determination of wastes that are hazardous to terrestrial organisms would be facilitated by (1) guidelines for using laboratory mammals and agricultural crops as surrogates for wild plants and animals, and (2) development of protocols for establishing significant exposure and effect levels for terrestrial organisms. Elements of such protocols might include selection of a standard set of organisms and endpoints of concern and development of standard exposure and intake assumptions for those organisms.

7.2.2.3 Subtitle C Permitting

Background Major Subtitle C permitting activities include issuing and modifying operating permits to all facilities that treat, store, or dispose of wastes defined as hazardous under Subtitle C of RCRA. Most new facilities are designed to ensure that hazardous wastes are not released into the environment, so surrounding ecosystems should be unaffected. Certain releases to the environment are permitted at existing facilities and some types of new facilities (e.g., air emissions from thermal treatment facilities). Most ecological assessments in support of permitting are conducted for the purpose of evaluating the level of cleanup required to address past releases rather than to determine the potential impacts from future releases.

Policy Issues There are three basic policy issues. The first is to determine what general types of ecological impacts, if any, to consider in permitting decisions. The second is to determine the types of facilities at which ecological impacts will be considered. For example, should ecological impacts be considered for all treatment, storage, and disposal facilities or only for those facilities listed as having a moderate to high risk potential within the RCRA program (i.e., facilities conducting activities pertaining to land disposal of hazardous wastes; PCB wastes; mixed wastes; and hazardous waste storage and treatment tanks, drums, and containers; the combustion of hazardous waste; land treatment of hazardous waste)? The final issue is to determine the extent to which permitting should focus on cleaning up past releases versus preventing future releases.

Methods Needs The major methods needs are (1) methods for evaluating actual ecological impacts that have resulted from past releases and for linking actual impacts with releases from specific sites, and (2) methods for identifying permitting conditions needed to prevent future ecological impacts, including selecting appropriate receptors and endpoints of concern (including sensitive species) and acute and chronic exposure levels likely to result in significant ecological impacts.

Available Methods Numerous methodological approaches and techniques are available within OSWER and have been used in RCRA Subtitle C permitting decisions. These include methods for characterizing actual ecological impacts (i.e., evaluation of biotic community structure, analysis of the morphological/physiological condition of individual organisms, and detailed field population studies) and methods for characterizing potential impacts (i.e., evaluation of exposure potential, comparison of environmental concentrations of contaminants with ecological benchmarks, evaluation of hazard potential using media toxicity tests, and quantitative risk modeling). In addition, NPDES permit protocols developed by EPA's Office of Water establish significant exposure levels for freshwater and marine life using media toxicity tests.

Opportunities for Methods Development Existing ecological assessment methods generally are adequate for Subtitle C permitting activities, although most of the general opportunities for making these methods more comprehensive and standardized are relevant to this program. The most important of these to Subtitle C permitting activities are derivation of additional benchmarks, guidance in the use of toxicity tests, characterizing hazards from single and multiple contaminants, and data needs (Exhibit 21). One specific area of methods development is especially important: methods for evaluating potential ecological impacts associated with permitted releases at certain types of facilities (e.g., air emissions from thermal treatment facilities or incinerators).

Two specific areas of guidance appear to be particularly important to Subtitle C permitting. The first is to include other pertinent agencies and expertise (e.g., the U.S. Fish and Wildlife Service, NOAA) in the permitting process as early as possible. This would maximize the opportunities for individuals trained and experienced in ecological assessments to review permit applications. Formation of RCRA regional bioassessment groups or involving RCRA personnel in CERCLA bioassessment groups might be an expeditious means by which this can be accomplished. The second area is developing guidelines and protocols for including environmental assessments and exposure information as an integral part of the permit decision process, particularly for the purpose of identifying potential ecological problems associated with part B permit applications. This might reduce the number of future corrective actions.

7.2.2.4 Subparts F and S Corrective Action

Background Corrective action under Subpart F is triggered at certain hazardous waste treatment, storage, and disposal facilities (TSDFs) when constituent concentrations in ground water exceed either background concentrations or MCLs. Owners or operators of TSDFs may petition to modify their permit conditions to set the levels of hazardous constituents that are allowed in the ground water at an alternate concentration level (ACL) based on the hydrogeologic characteristics of the site and the expected threat to human health and the environment resulting from exposure to these constituents. Ecological receptors are implicitly protected by requiring cleanup when background levels are exceeded. The main activities under Subpart F corrective action are identification and management of corrective action remedial measures and review of ACL petitions to determine whether the suggested ACL levels are appropriate and the facility permit conditions should be modified accordingly.

Corrective action under Subpart S is quite similar to the CERCLA remedial process. The first part of the process is the RCRA Facility Assessment (RFA), an inspection of facilities to determine whether past releases of hazardous wastes have occurred. If a facility is found to have experienced a release, a more detailed investigation, the RCRA Facility Investigation (RFI), is conducted to determine the extent of contamination. Corrective action is triggered at those facilities that are found through the RFI to have released hazardous constituents in concentrations that pose a threat to human health or the environment. In such instances, the owner or operator of the facility is required to conduct a Corrective Measures Study (CMS) to identify alternative remedies. EPA then will oversee implementation of the remedy by the owner or operator. The major actions under Subpart S corrective Action will be conducting RCRA Facility Assessments (RFAs), RCRA Facility Investigations (RFIs), and Corrective Measures Studies (CMSs) and overseeing implementation of the remedy.

Basic Policy Issues Guidance and regulations for the ACL process clearly require that ecological impacts as well as human health impacts be considered when setting ACLs. Petitioners often base their requested ACLs on ecological toxicity data for the constituents in question because environmental exposures are more likely than human exposures in most facility settings. However, no specific effects of concern have been established. The basic policy issue under both Subpart F and Subpart S corrective action is what general types of ecological impacts (including impacts to terrestrial ecosystems) to consider in permitting decisions and what level of impact will warrant Agency action.

Methods Needs The major methods needs under Subpart F corrective action are (1) screening-level protocols at the initial stages of the process to identify when ecological impacts should be considered, and (2) methods for characterizing actual and potential ecological impacts, including selecting appropriate receptors and endpoints of concern, identifying sensitive species or ecosystems, and determining acute and chronic exposure levels likely to result in significant ecological impacts.

The major methods needs under Subpart S corrective action are (1) screening-level protocols for setting priorities for RFAs (and possible incorporation of ecological considerations in such priority-setting), (2) procedures for conducting RFIs, including characterization of actual and/or potential ecological impacts, (3) definition of appropriate contaminant concentration levels in air, water, and soil that exceed ecological benchmarks and thus trigger corrective action, (4), procedures for including ecological impacts in a CMS, and (5) procedures for setting remedial cleanup standards that incorporate ecological considerations.

Available Methods Numerous methodological approaches and techniques for characterizing ecological impacts are available within OSWER and could be used in the corrective action programs (see Exhibit 20). Methods for characterizing actual ecological impacts include evaluation of biotic community structure, analysis of the morphological/physiological condition of individual organisms, and detailed field population studies. Methods for characterizing potential ecological impacts include evaluation of exposure potential, comparison of environmental concentrations of contaminants with ecological benchmarks, evaluation of hazard potential using media toxicity tests, and quantitative risk modeling. Ambient water quality criteria (AWQC) and advisories (AWQA) developed by EPA's Office of Water establish significant exposure levels for freshwater and marine life using single-constituent toxicity tests. NPDES permit protocols developed by EPA's Office of Water establish significant exposure levels for freshwater and marine life using multiple-constituent toxicity tests (media toxicity tests). Finally, levels of concern for changes in community diversity indices have been developed for some types of aquatic ecosystems by the Ohio Environmental Protection Agency.

Opportunities for Methods Development Existing ecological assessment methods generally are adequate for Subpart F and Subpart S corrective action activities, although most of the general opportunities for making these methods more comprehensive and standardized are relevant to these programs. The most important of these to corrective action are receptor characterization, characterizing hazard from single and multiple contaminants, derivation of ecological benchmarks, guidance in the use of media toxicity tests, defining the ecological significance of impacts, and data needs (Exhibit 21).

Development of guidance in two specific areas also is important: (1) applying ambient water quality criteria and advisories and/or toxicity data, including safety factors, to evaluate potential ecological impacts, and (2) evaluating ecological changes over time to establish whether or not a given corrective action was effective. One specific opportunity for methods development important for corrective action is a Hazard Ranking System (HRS)-type site screening method to identify facilities with potential for ecological impacts. For facilities with actual or potential impacts to terrestrial ecosystems, other important opportunities are the development of methods for evaluating potential ecological impacts to terrestrial ecosystems and establishing cleanup criteria in soils.

7.2.3 Opportunities for Methods Development in CERCLA Programs and Activities

In this section, opportunities for methods development are outlined for four CERCLA programs or activities: the removal program, pre-remedial activities, selection of remedy, and implementation and completion of remedy. Each is described in a separate section below.

7.2.3.1 Removal Program

Background Emergency removal actions generally occur in response to time-critical situations involving actual or potential releases of hazardous substances. The main tasks of the removal program are to identify situations that require emergency removal actions, take appropriate action to mitigate immediate hazards to human health and the environment, and verify that the immediate hazards are mitigated.

Basic Policy Issues Basic policy issues include whether ecological hazards should be considered when contemplating removals, emergency removal actions should be initiated because of ecological concerns, and ecological concerns should be used to determine the extent of a removal.

Methods Needs The major methods need is a screening-level protocol for quickly assessing whether removal action is needed based upon limited ecological data.

Available Methods Currently there is no specified method for identifying situations that require emergency removal actions on the basis of acute ecological hazards or verifying that these hazards have been mitigated as the result of removal activities. The screening-level methods reviewed in this report are not adequate for the removal program because they provide limited information for site-specific decisions.

Opportunities for Methods Development The methods development opportunities suggested in Chapter 6 are not particularly relevant for the removal program. Two different types of opportunities are possible ways to incorporate ecological information into the removal decision process. The first would be to include a trained ecologist in the emergency response teams and to rely on his or her professional judgment to make the appropriate decisions. The second approach would be to develop a simple rapid assessment technique, based on limited data, that would not require extensive ecological expertise. One approach to such a technique would be to employ simple qualitative or quantitative criteria (e.g., presence of a threshold quantity of a substance) to trigger a removal action. Another potential method would be a model that follows the basic approach of the Hazard Ranking System (HRS) used in the remedial program (i.e., an evaluation of chemical hazard, exposure potential, and targets of concern).

7.2.3.2 Pre-Remedial Activities

Background To allocate Superfund program resources efficiently and set priorities for further investigation and action, sites that pose the greatest hazards to health, welfare, and the environment must be identified. The first stage in the screening process is the Preliminary Assessment (PA). The PA is generally a low-cost initial evaluation of the magnitude of the potential hazard and the source and nature of any release. The PA does not normally include a site visit or sampling. At this stage, a yes/no decision is made as to whether conditions at the site might warrant further action by the Superfund program.

If results of the PA suggest that further action might be warranted, the next stage in the screening process is the Site Investigation (SI). Site-specific data on chemical hazard, exposure potential, and nearby targets are evaluated with a numeric scoring model, the Hazard Ranking System (HRS). Sites which score above a threshold value (28.5) are placed on the National Priorities List (NPL). Because of the large number of PAs and SIs that must be made, screening assessments must be conducted within constrained time and financial budgets. In discussing methods development opportunities at the PA and SI stages of the remedial process, consideration must be given both to the basic tasks outlined above and these constraints.

Basic Policy Issues The basic policy issue is the extent to which ecological impacts should be considered in determining whether or not further action is required at a Superfund site. At the PA stage, there is no clear policy articulating the extent to which ecological hazards must be considered. At the SI stage, the Superfund Amendments and Reauthorization Act of 1986 (SARA) requires that the HRS be revised so that "to the maximum extent feasible, [it] accurately assesses the relative degree of risk to human health and the environment posed by sites and facilities subject to review ..." (Section 105(c)(1)).

Methods Needs The major methods need is a screening-level protocol for quickly assessing whether further action by Superfund is needed based upon limited ecological data.

Available Methods At the SI stage, some ecological hazards are considered in the HRS, and the proposed revisions to the HRS include a more extensive characterization of potential ecological hazards. However, the proposed revised HRS scores only potential hazards to sensitive environments, focusing primarily on aquatic ecosystems.

Opportunities for Methods Development None of the methods development opportunities suggested in Chapter 6 are relevant for pre-remedial activities. Two different types of opportunities are possible ways to incorporate more ecological information into the screening-level decision process. At the PA stage, a screening methodology that incorporated salient features of the HRS (e.g., presence of sensitive environments within a target distance from the site) might provide a consistent means to identify sites with potential ecological hazards. At the SI stage, methods for incorporating information on observed effects, hazards to terrestrial organisms or non-sensitive ecosystems, and non-human food chain exposures into the HRS would improve its ability to prioritize sites on the basis of ecological hazards.

7.2.3.3 Selection of Remedy

Background Once a site is placed on the NPL, Superfund-financed remediation can begin. The first part of the remedial process is a detailed study of the site that culminates in a legal agreement between EPA and the responsible parties, if any, that outlines the mitigative actions to be taken and the cleanup criteria to be met in the remediation. The first step in this process is the Remedial Investigation (RI), a detailed study that characterizes the types and concentrations of contaminants in all media, the areal extent of actual and potential contamination, the types and number of human and ecological targets actually or potentially exposed to contaminants, and the actual or potential adverse effects to health, welfare, and the environment. In the Feasibility Study (FS), information collected during the RI is used to develop and evaluate cleanup alternatives on the basis of expected costs and benefits. The selection of remedial alternatives is formalized and explained in the Record of Decision (ROD).

Basic Policy Issues There is a general policy under Superfund to protect human health and the environment. For example, CERCLA and the National Contingency Plan (NCP) mandate the protection of natural resources, and the Department of the Interior regulations set forth procedures for conducting natural resource damage assessments. Moreover, CERCLA cleanups are required to comply with ARARS, some of which are related to environmental protection. At present, however, it is unclear how consistently this general policy of protection of the environment is being implemented at NPL sites.

Methods Needs The major methods needs for this part of the remedial process are (1) methods for characterizing actual and potential ecological impacts, including selecting appropriate receptors and endpoints of concern, identifying sensitive species or ecosystems, and determining acute and chronic exposure levels likely to result in significant ecological impacts, (2) protocols for setting remedial cleanup standards that incorporate ecological considerations, and (3) protocols for including ecological impacts in the final selection of remedy.

Available Methods Numerous methodological approaches and techniques for characterizing ecological impacts are available within OSWER and are being used in the Superfund remedial program (see Exhibit 20). Methods for characterizing actual ecological impacts include evaluation of biotic community structure, analysis of the morphological/physiological condition of individual organisms, and detailed field population studies. Methods for characterizing potential ecological impacts include evaluation of exposure potential, comparison of environmental concentrations of contaminants with ecological benchmarks, evaluation of hazard potential using media toxicity tests, and quantitative risk modeling. Ambient water quality criteria (AWQC) and advisories (AWQA) developed by EPA's Office of Water establish significant exposure levels for freshwater and marine life using single-constituent toxicity tests. NPDES permit protocols developed by EPA's Office of Water establish significant exposure levels for freshwater and marine life using multiple-constituent toxicity tests (media toxicity tests). Finally, levels of concern for changes in community diversity indices have been developed for some types of aquatic ecosystems by the Ohio Environmental Protection Agency.

Opportunities for Methods Development Existing ecological assessment methods generally are adequate for activities involved in selection of a remedy at NPL sites, although most of the general opportunities for making these methods more comprehensive and standardized are relevant to these activities. The most important of these in selection of a remedy are receptor characterization, characterizing hazard from single and multiple contaminants, derivation of ecological benchmarks, guidance in the use of media toxicity tests, defining the ecological significance of impacts, data needs, and a quantitative ecological risk model (Exhibit 21). Data and methods for assessing ecological impacts to terrestrial ecosystems and evaluating the ecological hazard of contaminants in soil, air, and sediments are of particular importance. Guidance in selecting the appropriate receptors, endpoints, benchmarks, approaches and techniques, and level of effort to devote to ecological assessments at a particular site, and in interpreting the results of ecological assessments for risk management decisions at that site, also is important.

7.2.3.4 Implementation and Completion of Remedy

Background Once a remedial action is specified for a site in its ROD, the remedial design and remedial action processes begin. After the remedies are in place or have been completed, the site enters the operation and maintenance stage. The main tasks during these stages are to ensure that the goals of the ROD are met and that adequate protection of health and the environment are maintained. Although the EPA Superfund program provides oversight for all sites undergoing remediation, it does not manage actual remedial activities. Management is provided by the U.S. Army Corps of Engineers for Superfund-lead sites and by States and responsible parties for those sites for which they have lead responsibility. States have the responsibility for operation and maintenance activities once the remedial actions have been completed.

Basic Policy Issues The basic policy issue is the extent to which ecological receptors must be protected during a remedial action and how human health and ecological concerns must be balanced during implementation and completion of the remedy.

Methods Needs The main methods needs are protocols to determine whether or not adverse ecological effects are occurring during implementation and completion of the remedy.

Available Methods Currently there are no standard protocols for monitoring the ecological effects associated with ongoing remedial activities. Several of the methodological approaches and techniques for characterizing ecological impacts currently used within OSWER could be applied for this purpose (see Exhibit 20). Methods for monitoring ongoing remedial activities might include use of in situ toxicity tests, monitoring contaminant concentrations in media or biota, and conducting field studies to monitor the status of biotic populations that might be affected by remedial activities. Changes in community diversity indices, such as those developed by the Ohio Environmental Protection Agency (Ohio EPA 1988), also could be used for this purpose. Long-term monitoring might be the only way to determine whether or not certain ecological goals of the ROD (e.g., reduction of tissue residue levels of persistent substances) have been met and continue to be met following completion of remedial activities.

Opportunities for Methods Development Existing ecological assessment methods generally are adequate for activities involved in implementation and completion of the remedy at an NPL site, and many of the general opportunities for making these methods more comprehensive and standardized are relevant to these activities. Of particular importance are derivation of ecological benchmarks, guidance in the use of media toxicity tests, and data needs (Exhibit 21). The primary data needs appear to be information on the natural range of variation in end points used in the monitoring process. These ranges might be used to establish threshold levels that would serve as early warning signs of potential adverse effects.

CHAPTER 8

LITERATURE CITED

Barnthouse, L.W., Suter, G.W., Bartell, S.M., Beauchamp, J.J., Gardner, R.H., Linder, E., O'Neill, R.V., and Rosen, A.E. 1986. User's Manual for Ecological Risk Assessment. Environmental Sciences Division Publication No. 2679. Oak Ridge National Laboratory, Oak Ridge, TN

Environmental Protection Agency (EPA). 1987. Acute Toxicity Handbook of Chemicals to Estuarine Organisms. Environmental Research Laboratory, Gulf Breeze, FL, April 1987. EPA/600-8-87-017.

Environmental Protection Agency/Office of Policy Analysis (EPA/OPA). 1989a. The Nature and Extent of Ecological Risks at Superfund Sites and RCRA Facilities. Washington, D.C., June, 1989. EPA/230-03-89-043.

Environmental Protection Agency/Office of Policy Analysis (EPA/OPA). 1989b. Ecological Risk Management in the Superfund and RCRA Programs. Washington, D.C., June, 1989. EPA/230-03-89-045.

Environmental Protection Agency/Office of Policy Analysis (EPA/OPA). 1988. Review of Ecological Risk Assessment Methods. Washington, D.C., November, 1988. EPA/230-10-88-041.

Environmental Protection Agency/Office of Policy Analysis/Office of Policy, Planning, and Evaluation (EPA/OPA/OPPE). 1987. Unfinished Business: A Comparative Assessment of Environmental Problems. Washington, D.C., February, 1987.

Environmental Protection Agency/Office of Pesticide Programs (EPA/OPP). 1986. Hazard Evaluation Division. Standard Evaluation Procedure, Ecological Risk Assessment. Washington, D.C., June 1986. EPA/540-9-85-001.

Environmental Protection Agency/Office of Solid Waste (EPA/OSW). 1984. The RCRA Cost-Analysis Model. Phase III Report. Submitted to the Office of Solid Waste Economic Analysis Branch, Washington, D.C., March 1, 1984.

Environmental Protection Agency/Office of Solid Waste (EPA/OSW). 1987a. Technical Resource Document for Variances from the Secondary Containment Requirements of Hazardous Waste Tank Systems. Volume II: Risk-based Variance. Washington, D.C., 1987.

Environmental Protection Agency/Office of Solid Waste (EPA/OSW). 1987b. Onshore Oil and Gas Exploration, Development, and Production: Human Health and Environmental Risk Assessment. Technical Support Document to Report to Congress. Washington, D.C., December, 1987.

Environmental Protection Agency/Office of Solid Waste (EPA/OSW). 1988a. Ecological Risk Characterization Methodology. Final Report. Washington, D.C., April 1988.

Environmental Protection Agency/Office of Solid Waste (EPA/OSW). 1988b. Solid Waste from Selected Metallic Ore Processing Operations. Draft Report to Congress. Washington, D.C., July 15, 1988.

Environmental Protection Agency/Office of Solid Waste and Emergency Response (EPA/OSWER). 1985. Wastes from the Extraction and Beneficiation of Metallic Ores, Phosphate Rock, Asbestos, Overburden from Uranium Mining, and Oil Shale. Report to Congress. Washington, D.C., December 1985. EPA/530-SW-85-033.

Environmental Protection Agency/Office of Solid Waste and Emergency Response (EPA/OSWER). 1988. Wastes from the Combustion of Coal by Electric Utility Power Plants. Report to Congress. Washington, D.C., February, 1988. EPA/530-SW-88-002.

Environmental Protection Agency/Office of Toxic Substances (EPA/OTS) 1984. Estimating "Concern Levels" for Concentrations of Chemical Substances in the Environment. Environmental Effects Branch, Health and Environmental Review Division, Washington, D.C. February, 1984.

Environmental Protection Agency/Office of Water (EPA/OW). 1985. Technical Support Document for Water Quality-based Toxics Control. Washington, D.C., September, 1985. EPA/440-4-85-032.

Environmental Protection Agency/Office of Water (EPA/OW). 1987. Permit Writer's Guide to Water-Quality Based Permitting for Toxic Pollutants. Washington, D.C., July, 1987. EPA/440-4-87-005.

ICF Incorporated. 1987. Regional and State Comparative Risk Project: Approaches for Ranking based on Ecological Risk/Impact. Working Paper prepared for the Office of Policy Analysis, U.S. Environmental Protection Agency, Washington, D.C., December 14, 1987.

ICF Incorporated. 1988a. Availability of Ecological Criteria for Aquatic Organisms for Substances of Concern Under CERCLA and RCRA. Draft report prepared for the Office of Policy Analysis, U.S. Environmental Protection Agency, Washington, D.C. August 3, 1988.

ICF Incorporated. 1988b. Comparison of Ecological Criteria with Health-Based Criteria and with Quantitation Limits. Draft report prepared for the Office of Policy Analysis, U.S. Environmental Protection Agency, Washington, D.C. August 2, 1988.

ICF Incorporated. 1988c. Status of the Development of EPA Ambient Water Quality Criteria. Memorandum to Craig Zamuda, Dexter Hinckley, and Michael Cox, Office of Policy Analysis, U.S. Environmental Protection Agency, Washington, D.C. August 15, 1988.

ICF Incorporated. 1988d. Ecological Risk Assessment Needs in the RCRA and CERCLA Programs. Memorandum to Michael Cox, Office of Policy Analysis, U.S. Environmental Protection Agency, Washington, D.C. September 2, 1988.

Ohio Environmental Protection Agency (Ohio EPA). 1988. Biological Criteria for the Protection of Aquatic Life: Volume I. The Role of Biological Data in Water Quality Assessment. Volume II. User's Manual for Biological Field Assessment of Ohio Surface Waters. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Suter, G.W.,II, Vaughan, D.S., and Gardner, R.H. 1983. Risk assessment by analysis of extrapolation error: A demonstration for effects of pollutants on fish. Environ. Toxicol. Chem. 2: 369-378.

Technical Resources Incorporated (TRI). 1987. Ecological Risk Assessment, End Points Selection Criteria. Draft Report Prepared for the Exposure Assessment Group, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Fish and Wildlife Service (USFWS). 1986. Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals. U.S. Department of the Interior, Washington D.C. Resource Publication 160, 1986.

APPENDICES

TABLE OF CONTENTS

EXHIBIT A-1: LIST OF CERCLA SITES REVIEWED (ALPHABETIZED BY REGION) ... i

EXHIBIT A-2: LOCATION (EPA REGION) OF CERCLA SITES AND RCRA FACILITIES REVIEWED ... ii

APPENDIX A: SUMMARY OF SITE-SPECIFIC METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS ... A-1

APPENDIX B: SUMMARY OF SITE-SPECIFIC METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS ... B-1

APPENDIX C: SITE-BY-SITE LISTING OF METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS ... C-1

APPENDIX D: SITE-BY-SITE LISTING OF METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS ... D-1

APPENDIX E: GLOSSARY OF ENTRIES IN APPENDICES ... E-1

PREFACE

In these Appendices, we list and summarize elements of site-specific methods used to characterize actual and potential ecological impacts at CERCLA and RCRA sites, as reported in the site-specific documents we obtained. The name and location (EPA Regions) of each site or facility reviewed are listed in Exhibits A-1 and A-2.

Elements of methods used to characterize actual ecological impacts are organized according to the type of ecosystem (i.e., terrestrial, terrestrial associated with aquatic[1], freshwater, estuarine, marine, and wetland) to which they were applied. For each ecosystem of concern, we list the elements used to characterize receptors and the general approach used to characterize these impacts. Receptors are classified according to the biotic level of organization (i.e., ecosystem, community, population, individual), taxonomic group of organism (e.g., bird, mammal, invertebrate, plant), and specific ecological endpoint used (e.g., reproduction, community diversity). Approaches used to characterize impacts are classified according to the type of method employed (e.g., qualitative survey of the ecosystem, systematic field sampling, media bioassay), the type of ecological benchmark used (e.g., lowest-observed-effect level, acute LC_{50}, ambient water quality criterion), and whether sampling points were selected on the basis of ecological concerns, human health concerns, or both. An analysis of the frequency with which each element was used is presented in Appendix A. A site-by-site listing of these elements is presented in Appendix C.

Elements of methods used to characterize potential ecological impacts are organized according to the type of ecosystem to which they were applied. For each ecosystem of concern, we list the elements used to characterize receptors, hazard, and exposure. Receptors are classified according to the biotic level of organization, taxonomic group of organism, and specific endpoint(s) used. Hazard is classified according to whether contaminants of concern were selected on the basis of ecological risks or human health, the type of site-specific toxicity measures (i.e., media bioassays) used, and the type of ecological benchmark used. Exposure is classified according to whether sampling points were selected to evaluate ecological or health risks, the exposure pathways considered (e.g., water column, food chain, ingestion of contaminated sediments), the types of assumptions used to estimate intake and/or dose, and how chemical concentrations at the receptor were determined. Methods also are classified according to which particular approaches to risk assessment were used. Elements of risk assessment include the general type of method used (e.g., qualitative evaluation, quotient method) and how impacts above threshold, areal extent, reversibility of impacts, and uncertainty of the risk assessment are characterized. An analysis of the frequency with which each element was used is presented in Appendix B. A site-by-site listing of these elements is presented in Appendix D.

A glossary of all entries in each Appendix is provided in Appendix E.

---

[1] An ecosystem in which terrestrial organisms might be exposed to contaminants through ingestion of contaminated surface water or aquatic biota.

EXHIBIT A-1

LIST OF CERCLA SITES REVIEWED (ALPHEBATIZED BY REGION)

EPA Region 1

O'Connor
Old Springfield Landfill
Re-Solve
Sullivan's Ledge
Confidential #1
Confidential #3
Confidential #6

EPA Region 2

Chemical Control
Clothier Site
Hudson River
Lipari Landfill
Marathon Battery

EPA Region 3

Army Creek Landfill
Chisman Creek
Delaware Sand and Gravel
Douglassville Disposal
L.A. Clarke
New Castle Steel
Palmerton Zinc
Tybout's Corner Landfill
Tyson's Dump
West Virginia Ordnance
Wildcat Landfill
Winchester Tire Fire Site

EPA Region 4

American Creosote Works
58th Street Landfill
Geiger Site
Harris Corporation
Mowbray Engineering
Munisport Landfill
Newport Dump
Parramore Surplus
Sapp Battery Salvage
62nd Street Dump
Stauffer Chemical Co.

EPA Region 5

Eau Claire
Fort Wayne Reduction
Fultz Landfill
Liquid Disposal
Marion/Bragg Landfill
Outboard Marine
Schmalz Dump
Seymour Recycling
Velsicol Site

EPA Region 6

Mid-South Wood Products
United Nuclear
Wichita Mountain

EPA Region 7

no sites

EPA Region 8

Confidential #2
Confidential #4

EPA Region 9

Iron Mountain Mine
Confidential #5

EPA Region 10

Queen City Farms

EXHIBIT A-2

LOCATION (EPA REGION) OF CERCLA SITES REVIEWED

Site Name	EPA Region	Site Name	EPA Region
American Creosote Works	4	Old Springfield Landfill	1
Army Creek Landfill	3	Outboard Marine	5
Chemical Control	2	Palmerton Zinc	3
Chisman Creek	3	Parramore Surplus	4
Clothier Site	2	Queen City Farms	10
Delaware Sand and Gravel	3	Re-Solve	1
Douglassville Disposal	3	Sapp Battery Salvage	4
Eau Claire	5	Schmalz Dump	5
58th Street Landfill	4	Seymore Recycling Corp.	5
Fort Wayne Reduction	5	62nd Street Site	4
Fultz Landfill	5	Stauffer Chemical Co.	4
Geiger Site	4	Sullivan's Ledge	1
Harris Corporation	4	Tybouts Corner Landfill	3
Hudson River	2	Tyson's Dump	3
Iron Mountain Mine	9	United Nuclear	6
LA Clarke	3	Velsicol Site	5
Lipari Landfill	2	West Virginia Ordnance	3
Liquid Disposal	5	Wichita Mountain	6
Marathon Battery	2	Wildcat Landfill	3
Marion/Bragg Landfill	5	Winchester Tire Fire Site	3
Mid-South Wood Products	6	Confidential #1	1
Mowbray Engineering	4	Confidential #2	8
Munisport Landfill	4	Confidential #3	1
New Castle Steel	3	Confidential #4	8
Newport Dump Site	4	Confidential #5	5
O'Connor	1	Confidential #6	1

LOCATION (EPA REGION) OF RCRA FACILITIES REVIEWED

Site Name	EPA Region	Site Name	EPA Region
Allied Chemical	3	Nat. Industr. Env. Serv.	7
ARCO Prudhoe Bay Unit	10	Pratt and Whitney	4
Defense General Supply	3	Rohm & Haas	3
International Paper Co.	7	SACO Defense, Inc	1
IRECO Chemicals	8	Southern Dye Co.	4
Kennedy Space Center	4	Southern Wood Piedmont	4
Koppers Company	5	Union Carbide Agricultural	4
Monroe Auto	4	Wyman-Gordon	1

APPENDIX A

SUMMARY OF SITE-SPECIFIC METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS

APPENDIX A

SUMMARY OF SITE-SPECIFIC METHODS USED TO EVALUATE ACTUAL ECOLOGICAL IMPACTS IN TERRESTRAL ECOSYSTEMS [a][b]

	RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
TERRESTRIAL (33)[c]	Ecosystem (1)	n/a (1)	Other[d] (1)	Field Sampling (1)	n/a (1)	Ecol (1)
	Community (14)	Plant (14)	Veget Absence (11)	Qualitative Survey (10)	Not Specified (14)	Ecol (13)
			Veget Stress (3)	Field Sampling (3)		Not Spec (1)
		Mammal (4)	Commun Divers (4)	Other[e] (1)		
		Bird (4)	Commun Divers (4)			
		Reptile (2)	Commun Divers (2)			
		Invert (2)	Commun Divers (2)			
		Other (1)	Commun Divers (1)			
	Population (1)	Bird (1)	Reproduction (1)	Field Sampling (1)	Not Specified (1)	Ecol (1)
			Behavior (1)			
	Individual (7)	Mammal (6)	Tissue Residue (3)	Field Sampling (5)	Background (6)	Ecol (5)
			Mortality (1)	Other[g][h] (2)	n/a (1)	Hum (1)
			Disease/Abnorm (1)			n/a (1)
			Other[f] (1)			
		Plant (2)	Tissue Residue (2)			
		Bird (2)	Mortality (1)			
			Tissue Residue (1)			
		Invert (1)	Tissue Residue (1)			
	Not Specif (2)	Not Specif (2)	Contam Media (2)	Media Sampling (2)	Detection (1)	Both (2)
					Background (1)	

---

[a] Number of sites given in parentheses

[b] For an explanation of entries, see Glossary (Appendix E)

[c] Impacts were not assessed at 11 sites

[d] See Palmerton Zinc Site (Appendix C)

[e] Aerial photography

[f] Chemical burns on lifestock straying into contaminated area

[g] Histopathological examination

[h] Historical records of bird carcasses

APPENDIX A (continued)

SUMMARY OF SITE-SPECIFIC METHODS USED TO EVALUATE ACTUAL ECOLOGICAL IMPACTS IN TERRESTRIAL ECOSYSTEMS ASSOCIATED WITH AQUATIC ECOSYSTEMS [a][b]

	RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
TERR-AQUATIC (8)[c]	Community (2)	Plant (2) Bird (2) Mammal (2) Amphibian (2) Reptile (2)	Commun Divers (2)	Qualitative Survey (2)	Not Specified (2)	Ecol (2)
	Individual (1)	Mammal (1)	Tissue Residue (1) Disease/Abnorm (1)	Field Sampling (1)	Background (1)	Ecol (1)

---

[a] Number of sites given in parentheses

[b] For an explanation of entries, see Glossary (Appendix E)

[c] Impacts were not assessed at five sites

APPENDIX A (continued)

SUMMARY OF SITE-SPECIFIC METHODS USED TO EVALUATE ACTUAL ECOLOGICAL IMPACTS IN FRESHWATER ECOSYSTEMS[a,b]

	RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
FRESHWATER (53)[c]	Community (21)	Invert (15)	Commun Divers (14)	Field Sampling (13)	Background (7)	Ecol (19)
			Indic Species (2)	Qualitative Survey (8)	Not Specified (14)	Both (2)
		Fish (13)	Commun Divers (12)			
		Plant (3)	Commun Divers (2)			
			Veget Stress (1)			
	Population (5)	Fish (5)	Mortality (5)	Other[d] (4)	Not Specified (5)	n/a (4)
			Growth (1)	Field Sampling (1)		Ecol (1)
			Migration (1)			
	Individual (21)	Fish (21)	Tissue Residue (19)	Field Sampling (18)	Background (13)	Ecol (11)
			Disease/Abnorm (8)	Other[e]/[f] (7)	FDA (4)	Hum (7)
		Invert (4)	Tissue Residue (4)	Bioass-In Situ (1)	Other[g] (1)	Both (3)
		Plant (2)	Tissue Residue (2)		Not Specified (4)	
		Amphibian (2)	Tissue Residue (2)			
		Reptile (1)	Tissue Residue (1)			
		Bird (1)	Tissue Residue (1)			
	Not Specif (13)	Not Specif (13)	Contam Media (12)	Media Sampling (12)	AWQC (10)	Both (6)
			Not Specified (1)	Qualitative Survey (1)	Local Std (2)	Ecol (3)
					Background (2)	Hum (3)
					Not Specif (2)	Not Spec (1)
					Mort-50 (1)	
					LOEL (1)	

---

[a] Number of sites given in parentheses

[b] For an explanation of entries, see Glossary (Appendix E)

[c] Impacts were not assessed at 13 sites

[d] Historical records of fish kills

[e] Data from STORET and other monitoring programs

[f] Histopathological examination and/or gross necropsy

[g] Species-specific contaminant levels determined by California Department of Fish and Game

APPENDIX A (continued)

SUMMARY OF SITE-SPECIFIC METHODS USED TO EVALUATE ACTUAL ECOLOGICAL IMPACTS IN ESTUARINE ECOSYSTEMS [a][b]

	RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
ESTUARINE (8)[c]	Community (4)	Invert (4)	Commun Divers (4)	Qualitative Survey[d] (2)	Background (2)	Ecol (4)
			Indic Species (1)	Field Sampling (2)	Not Specified (2)	
		Plant (1)	Commun Divers (1)			
		Fish (1)	Commun Divers (1)			
	Population (2)	Invert (2)	Tissue Residue (1)	Qualitative Survey[d] (1)	Background (1)	Ecol (2)
			Mortality (1)	Field Sampling (1)	n/a (1)	
	Individual (4)	Invert (3)	Tissue Residue (2)	Field Sampling (4)	Background (3)	Ecol (2)
			Disease/Abnorm (1)	Other[e] (1)	Not Specified (1)	Both (1)
		Fish (2)	Tissue Residue (1)			Hum (1)
			Disease/Abnorm (1)			
	Not Specif (2)	Not Specif (2)	Contam Media (2)	Media Sampling[d] (2)	AWQC (1)	Ecol (1)
					Background (1)	Both (1)

---

[a] Number of sites given in parentheses

[b] For an explanation of entries, see Glossary (Appendix E)

[c] Impacts were not assessed at one site

[d] At one site, data from sampling in nearby areas by Army Corps of Engineers and U.S. Fish and Wildlife Service

[e] Histopathological examination

APPENDIX A (continued)

SUMMARY OF SITE-SPECIFIC METHODS USED TO EVALUATE ACTUAL ECOLOGICAL IMPACTS IN MARINE ECOSYSTEMS a/b/

	RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
MARINE (1)	Not Specif (1)	Not Specif (1)	Contam Media (1)	Media Sampling (1)	Detection (1)	Both (1)

---

a/ Number of sites given in parentheses

b/ For an explanation of entries, see Glossary (Appendix E)

APPENDIX A (continued)

SUMMARY OF SITE-SPECIFIC METHODS USED TO EVALUATE ACTUAL ECOLOGICAL IMPACTS IN WETLAND ECOSYSTEMS [a/][b/]

	RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
WETLAND (26)[c/]	Community (12)	Plant (11)	Veget Stress (7)	Qualitative Survey (8)	Background (2)	Ecol (12)
			Commun Divers (5)	Other[d/] (3)	Not Specified (10)	
		Fish (4)	Commun Divers (4)	Field Sampling (2)		
		Bird (2)	Commun Divers (2)			
		Invert (2)	Commun Divers (2)			
		Mammal (1)	Commun Divers (1)			
		Amphibian (1)	Commun Divers (1)			
		Not Specif (1)	Commun Divers (1)			
		Other[e/] (1)	Commun Divers (1)			
	Population (1)	Plant (1)	Mortality (1)	Qual Survey (1)	Not Specified (1)	Ecol (1)
	Individual (7)	Plant (5)	Tissue Residue (2)	Field Sampling (6)	Background (6)	Ecol (6)
			Growth (2)	Qualitative Survey (1)	Not Specified (1)	Human (1)
			Mortality (1)			
			Reproduction (1)			
		Fish (2)	Tissue Residue (1)			
			Disease/Abnorm (1)			
		Reptile (1)	Tissue Residue (1)			
			Disease/Abnorm (1)			
		Mammal (1)	Tissue Residue (1)			
			Reproduction (1)			
		Amphibian (1)	Tissue Residue (1)			
		Other[f/] (1)	Tissue Residue (1)			
	Not Specif (6)	Not Specif (5)	Contam Media (4)	Media Sampling (4)	Background (3)	Ecol (4)
			Not Specif (1)	Not Specified (1)	AWQC (1)	Both (1)
		Plant (1)	Growth (1)	Media Sampling (1)	Other[g/] (1)	Not Spec (1)
			Not Specif (1)	Qualitative Survey (1)	Not Specified (2)	

[a/] Number of sites given in parentheses

[b/] For an explanation of entries, see Glossary (Appendix E)

[c/] Impacts were not assessed at seven sites

[d/] Aerial photography

[e/] Benthic algae

[f/] Zooplankton and phytoplankton

[g/] Soil concentration considered "toxic" to plants

APPENDIX B

SUMMARY OF SITE-SPECIFIC METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS

APPENDIX B

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN TERRESTRIAL ECOSYSTEMS [a/b]

	RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
TERRESTRIAL (31)[c]	Population (10)	Mammal (9)	Reproduction (3)	Ecol (4)	None (10)	Mort-50 (3)
			Mortality (3	Hum (4)		LOEL (3)
			Other[d/e] (3)	Both (2)		BAF (2)
			Not Specified (3)			NOEL (1)
		Bird (7)	Reproduction (3)			Other[f] (1)
			Mortality (3)			Not Spec (4)
			Other[d/e] (3)			
			Not Specified (1)			
		Reptile (1)	Mortality (1)			
		Invert (1)	Reproduction (1)			
		Plant (1)	Reproduction (1)			
			Mortality (1)			
			Other[e] (3)			
	Individual (3)	Bird (2)	Mortality (1)	Ecol (2)	None (2)	Other[h] (1)
			Other[g] (1)	Hum (1)	n/a (1)	Not Spec (1)
			Not Specified (1)			n/a (1)
		Mammal (2)	Mortality (2)			
			Other[g] (1)			
	Not Specif (6)	Not Specif (4)	Not Specif (6)	Hum (4)	None (6)	AWQC (1)
		Mammal (2)		Both (2)		Not Spec (5)
		Reptile (2)				
		Bird (1)				
		Amphibian (1)				
		Plant (1)				

---

[a] Number of sites given in parentheses

[b] For an explanation of entries, see Glossary (Appendix E)

[c] Impacts were not evaluated at 13 sites

[d] At one site, numerous endpoints were specified

[e] Unspecified "chronic effects"

[f] Soil concentration "toxic to plants"

[g] Deafening from explosions

[h] Tissue residue levels known to cause adverse effects

APPENDIX B (continued)

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN TERRESTRIAL ECOSYSTEMS (continued)

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Level of Organization	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
Population	Hum (5) Ecol (2) Both (2) N.S. (1)	Cont/Derm (8) Ingestion (6) Food Chain (5) Inhalation (1)	N.S. (6) Quant (3) n/a (1)	Measured (5) Modelled (3) Qual Eval (1) n/a (1)	Qual Eval (6) Quot-Sing (6)	Qual Eval (1) Not Spec (5) n/a (4)	Qual Eval (4) Not Specif (3) n/a (3)	Adequate (7) Inadequate (3)
Individual	Ecol (2) N.S. (1)	Cont/Derm (1) n/a (2)	Qual (1) N.S. (1) n/a (1)	Qual Eval (1) n/a (2)	Qual Eval (2) Quot-Sing (1)	Qual Eval (1) n/a (2)	Qual Eval (1) Not Specif (1) n/a (1)	Adequate (3)
Not Specified	Hum (2) Both (2) N.S. (1)	Cont/Derm (4) Food Chain (2) Ingestion (2) Inhalation (1) Not Specif (1)	Qual (1) N.S. (5)	Measured (2) Qual Eval (2) N.S. (2)	Qual Eval (6)	Not Spec (5) n/a (1)	Qual Eval (1) Not Specif (4) n/a (1)	Inadequate (5) Adequate (1)

APPENDIX B (continued)

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN TERRESTRIAL ECOSYSTEMS ASSOCIATED WITH AQUATIC ECOSYSTEMS [a/][b/]

	RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
TERR-AQUAT (21)[c/]	Population (3)	Mammal (3)	Reproduction (2)	Ecol (1)	None (3)	LOEL (2)
			Mortality (1)	Hum (1)		NOEL (1)
			Disease/Abnorm (1)	Both (1)		MORT-50 (1)
			Not Specified (1)			BCF (1)
		Bird (3)	Reproduction (2)			Not Spec (1)
			Mortality (1)			
			Disease/Abnorm (1)			
			Not Specified (1)			
		Reptile (1)	Reproduction (1)			
	Individual (2)	Mammal (2)	Tissue Residue (1)	Ecol (2)	None (2)	Not Spec (2)
			Reproduction (1)			
			Not Specif (1)			
		Bird (1)	Tissue Residue (1)			
			Reproduction (1)			
	Not Specif (2)	Plant (1)	Not Specif (2)	Hum (1)	None (2)	Not Spec (2)
		Mammal (1)		Both (1)		
		Bird (1)				
		Reptile (1)				
		Amphibian (1)				
		Not Spec (1)				

[a/] Number of sites given in parentheses

[b/] For an explanation of entries, see Glossary (Appendix E)

[c/] Impacts were not evaluated at 14 sites

APPENDIX B (continued)

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN TERRESTRIAL ECOSYSTEMS ASSOCIATED WITH AQUATIC ECOSYSTEMS (continued)

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Level of Organization	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
Population	Ecol (2)	Food Chain (3)	Quant (2)	Modelled (2)	Quot-Sing (2)	Qual Eval (2)	Qual Eval (2)	Adequate (3)
	Hum (1)	Ingestion (2)	n/a (1)	n/a (1)	Qual Eval (2)	n/a (1)	n/a (1)	
		Cont/Derm (1)						
Individual	Ecol (1)	Food Chain (2)	N.S. (2)	Measured (1)	Quot-Sing (1)	Not Spec (1)	Qual Eval (1)	Adequate (1)
		Ingestion (1)		Qual Eval (1)	Qual Eval (1)	n/a (1)	Not Specif (1)	Not Spec (1)
Not Specified	Both (1)	Cont/Derm (2)	Qual (1)	Measured (1)	Qual Eval (2)	Not Spec (2)	Not Specif (2)	Inadequate (2)
	N.S. (1)	Food Chain (1)	N.S. (1)	Not Specif (1)				
		Inhalation (1)						

APPENDIX B (continued)

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN FRESHWATER ECOSYSTEMS [a]/[b]

Ecosystem of Concern	RECEPTOR CHARACTERIZATION Level of Organization	 Taxonomic Group	 Type(s) of End Point(s)	HAZARD CHARACTERIZATION Selection of Contaminant(s) of Concern	 Site-Specific Toxicity Measure(s)	 Derivation of Benchmark
FRESHWATER (54)[c]	Community (3)	Invert (3)	Commun Divers (2)	Ecol (1)	n/a (3)	LOEL (1)
			Other[d] (1)	Hum (1)		Not Spec (2)
				Not Spec (1)		
	Population (18)	Fish (18)	Mortality (13)	Ecol (12)	Bioassay-Lab (7)	Other[e] (6)
			Reproduction (5)	Hum (5)	Bioassay-In Situ (1)	Mort-50 (6)
			Other[f] (5)	Both (2)	None (10)	LOEL (5)
			Growth (3)			AWQC (4)
			Not Specified (2)			Loc Std (3)
			Disease/Abnorm (1)			BCF (2)
			Migration (1)			Bkgd (2)
		Invert (13)	Mortality (10)			Not Spec (3)
			Reproduction (6)			
			Other[f] (3)			
			Growth (2)			
			Pop Density (1)			
			Respiration (1)			
			Osmoregulation (1)			
			Not Specified (1)			
		Plant (1)	Not Specified (1)			
	Individual (2)	Invert (1)	Tissue Residue (1)	Ecol (2)	Bioassay-In Situ (1)	Bkgd (2)
		Fish (1)	Tissue Residue (1)		None (1)	
		Reptile (1)	Tissue Residue (1)			
	Not Specif (31)	Not Spec (29)	Contam Media (29)	Hum (15)	None (31)	AWQC (28)
		Fish (2)	Not Specif (2)	Both (9)		Loc Std (7)
		Invert (1)		Ecol (7)		Mort-50 (4)
						BCF (2)
						LOEL (1)

---

[a] Number of sites given in parentheses

[b] For an explanation of entries, see Glossary (Appendix E)

[c] Impacts were not evaluated at nine sites

[d] Unspecified "community" effects

[e] 0% effect level in bioassay

[f] Unspecified "chronic" effects

APPENDIX B (continued)

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN FRESHWATER ECOSYSTEMS (continued)

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Level of Organization	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
Community	Ecol (1)	Sed-Contact (3)	n/a (3)	Modelled (2)	Qual Eval (3)	Qual Eval (1)	Qual Eval (1)	Adequate (2)
	Hum (1)	Water Col (3)		Measured (1)	Quot-Sing (1)	Not Spec (1)	Not Specif (1)	Inadequate (1)
	N.S. (1)	Sed-Ingest (2)				n/a (1)	n/a (1)	
Population	Ecol (12)	Water Col (18)	n/a (18)	Measured (7)	Quot-Sing (11)	Qual Eval (4)	Qual Eval (3)	Adequate (12)
	Hum (5)	Sed-Contact (2)		Modelled (6)	Bioassay (8)	Not Spec (11)	Quant Estim (1)	Inadequate (4)
	N.S. (1)	Sed-Ingest (2)		Qual Eval (1)	Qual Eval (2)	n/a (3)	Not Specif (11)	Not Specif (2)
		Food Chain (2)		n/a (6)			n/a (3)	
Individual	Ecol (2)	Sed-Contact (1)	Qual (1)	n/a (2)	Bioassay (1)	Qual Eval (1)	Qual Eval (1)	Adequate (1)
		Sed-Ingest (1)	n/a (1)		Quot-Sing (1)	Not Spec (1)	Not Specif (1)	Not Specif (1)
		Water Col (1)						
Not Specified	Hum (12)	Water Col (26)	n/a (31)	Measured (20)	Quot-Sing (27)	Qual Eval (2)	Qual Eval (5)	Adequate (14)
	Both (11)	Sed-Contact (3)	Quant (1)	Modelled (11)	Qual Eval (4)	Not Spec (24)	Not Specif (22)	Inadequate (14)
	Ecol (6)	Sed-Ingest (3)		Qual Eval (1)		n/a (5)	n/a (4)	Not Specif (3)
	N.S. (2)	Food Chain (2)		Not Specif (1)				
		Not Specif (5)						

APPENDIX B (continued)

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN ESTUARINE ECOSYSTEMS [a][b]

	RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
ESTUARINE (7)	Ecosystem (1)	Fish (1)	Reproduction (1)	Both (1)	None (1)	AWQC (1)
						LOEL (1)
						Mort-50 (1)
						Other[c] (1)
	Community (1)	Fish (1)	Commun Divers (1)	Both (1)	None (1)	AWQC (1)
		Invert (1)	Commun Divers (1)			LOEL (1)
		Plant (1)	Commun Divers (1)			Mort-50 (1)
						Other[c] (1)
	Population (4)	Invert (3)	Mortality (3)	Ecol (3)	Bioassay-Lab (4)	Other[d] (4)
			Reproduction (1)	Both (1)		
			Growth (1)			
		Fish (2)	Mortality (2)			
			Reproduction (1)			
			Growth (1)			
		Plant (2)	Mortality (2)			
			Reproduction (1)			
			Growth (1)			
		Not Spec (1)	Mortality (1)			
	Not Specif (4)	Not Spec (4)	Contam Media (4)	Both (2)	None (4)	AWQC (4)
				Hum (1)		Loc Std (1)
				Ecol (1)		

---

[a] Number of sites given in parentheses

[b] For an explanation of entries, see Glossary (Appendix E)

[c] Site-specific sediment criterion

[d] 0% effect level bioassay

APPENDIX B (continued)

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN ESTUARINE ECOSYSTEMS (continued)

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Level of Organization	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
Ecosystem	Both (1)	Water Col (1) Sed-Contact(1) Sed-Ingest (1) Food Chain (1)	Quant (1)	Measured (1) Modelled (1)	Quant Model (1)	Qual Eval (1)	Qual Eval (1)	Adequate (1)
Community	Both (1)	Water Col (1) Sed-Contact(1) Sed-Ingest (1) Food Chain (1)	Quant (1)	Measured (1) Modelled (1)	Quot-Sing (1)	Quant Est (1)	Quant Est (1)	Adequate (1)
Population	Ecol (3) Both (1)	Water Col (3) Sed-Contact (1) Sed-Ingest (1)	n/a (4)	n/a (4)	Bioassay (4)	Qual Eval (1) Not Spec (3)	Not Specif (4)	Adequate (3) Not Specif (1)
Not Specified	Both (3) Ecol (1)	Water Col (4)	n/a (4)	Measured (3) Modelled (3)	Quot-Sing (4)	Not Spec (4)	Quant Estim (1) Qual Eval (1) Not Specif (2)	Adequate (2) Inadequate (2)

APPENDIX B (continued)

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN MARINE ECOSYSTEMS [a][b]

	RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
MARINE (2)	Population (1)	Plant (1)	Mortality (1)	Ecol (1)	Bioassay-Lab (1)	Other[c] (1)
			Reproduction (1)			
		Invert (1)	Mortality (1)			
			Reproduction (1)			
	Not Specif (2)	Not Spec (2)	Contam Media (2)	Hum (1)	None (2)	AWQC (2)
				Ecol (1)		

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Level of Organization	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
Population	Ecol (1)	Water Col (1)	n/a (1)	n/a (1)	Bioassay (1)	Not Spec (1)	Not Specif (1)	Adequate (1)
		Sed-Contact (1)						
		Sed-Ingest (1)						
Not Specified	Both (1)	Water Col (1)	n/a (2)	Measured (2)	Quot-Sing (2)	Not Spec (2)	Not Specif (2)	Adequate (1)
	Ecol (1)	Food Chain (1)						Inadequate (1)
		Not Specif (1)						

---

[a] Number of sites given in parentheses

[b] For an explanation of entries, see Glossary (Appendix E)

[c] 0% effect level in bioassay

APPENDIX B (continued)

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN WETLAND ECOSYSTEMS [a][b]

	RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Ecosystem of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
WETLAND (25)[c]	Community (3)	Invert (1)	Commun Divers (1)	Ecol (2)	None (1)	LOEL (1)
		Plant (1)	Commun Divers (1)	Not Spec (1)	n/a (1)	Bkgd (1)
		Not Spec (1)	Not Specified (1)			Not Spec (1)
	Population (7)	Fish (4)	Mortality (3)	Ecol (4)	None (4)	LOEL (3)
			Reproduction (2)	Hum (2)	Bioassay-Lab (3)	Other[d][e] (3)
			Growth (1)	Not Spec (1)		Mort-50 (1)
			Other[f] (1)			NOEL (1)
		Invert (4)	Mortality (3)			AWQC (1)
			Reproduction (3)			Bkgd (1)
			Growth (2)			
			Pop Density (1)			
		Plant (2)	Mortality (2)			
			Reproduction (1)			
		Mammal (2)	Reproduction (1)			
			Not Specified (1)			
		Bird (1)	Not Specified (1)			
		Not Spec (1)	Mortality (1)			
	Individual (1)	Plant (1)	Not Specified (1)	Ecol (1)	None (1)	Not Spec (1)
		Reptile (1)				
		Amphibian (1)				
	Not Specif (10)	Not Spec (9)	Contam Media (7)	Hum (5)	None (10)	AWQC (7)
			Not Specified (1)	Both (3)		Loc Std (1)
		Plant (1)	Not Specif (1)	Ecol (2)		Not Spec (4)

---

[a] Number of sites given in parentheses

[b] For an explanation of entries, see Glossary (Appendix E)

[c] Impacts were not evaluated at eight sites

[d] Unspecified "ecotoxicity test results"

[e] 0% effect level in bioassay

[f] Unspecified "chronic effects"

SUMMARY OF METHODS USED TO EVALUATE POTENTIAL ECOLOGICAL IMPACTS IN WETLAND ECOSYSTEMS (continued)

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Level of Organization	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
Community	Ecol (2) N.S. (1)	Water Col (3) Sed-Contact (2) Sed-Ingest (1) Food Chain (1)	Quant (1) n/a (2)	Measured (2) Modelled (1) Qual Eval (1)	Qual Eval (3) Quot-Sing (1)	Qual Eval (1) n/a (2)	Qual Eval (2) n/a (1)	Inadequate (2) Adequate (1)
Population	Hum (3) Ecol (3) N.S. (1)	Water Col (7) Contact/Derm (2) Food Chain (2) Sed-Contact (2) Sed-Ingest (1)	Quant (1) N.S. (1) n/a (5)	Measured (3) Modelled (3) n/a (3)	Quot-Sing (4) Bioassay (3) Qual Eval (2)	Qual Eval (1) Not Spec (3) n/a (3)	Qual Eval (1) Not Specif (3) n/a (3)	Adequate (5) Inadequate (1) Not Specif (1)
Individual	N.S. (1)	Water Col (1) Sed-Contact (1)	N.S. (1)	Qual Eval (1)	Qual Eval (1)	n/a (1)	Qual Eval (1)	Adequate (1)
Not Specified	Hum (5) Both (3) Ecol (1) n/a (1)	Water Col (7) Sed-Contact (3) Sed-Ingest (3) Food Chain (3) Ingestion (3) Not Specif (2) n/a (1)	Qual (1) n/a (10)	Measured (8) Qual Eval (3)	Quot-Sing (7) Qual Eval (4)	Qual Eval (1) Not Spec (9)	Qual Eval (1) Not Specif (9)	Inadequate (8) Adequate (2)

APPENDIX C

SITE-BY-SITE LISTING OF METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS

APPENDIX C

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
EPA REGION 1							
O'CONNER	TERRESTRIAL	COMMUNITY	PLANT, BIRD, MAMM	COM DIV	QUAL SURV	N/A	ECO
	TERR-AQUATIC	COMMUNITY	PLANT, BIRD, MAMM, AMPHIB	COM DIV	QUAL SURV	N/A	ECO
	FRESHWATER	COMMUNITY	FISH	COM DIV	QUAL SURV	N/A	ECO
		INDIVIDUAL	FISH, AMPHIB	TIS RES	FIELD SAMP	BKGD[a]/	ECO
	WETLAND	COMMUNITY	PLANT, AMPHIB	COM DIV	QUAL SURV	N/A	ECO
		INDIVIDUAL	AMPHIB	TIS RES	FIELD SAMP	BKGD[a]/	ECO
OLD SPRINGFIELD LANDFILL	TERRESTRIAL	NOT SPECIFIED[b]/					
	TERR-AQUATIC	NOT SPECIFIED[b]/					
	FRESHWATER	NOT SPECIFIED[b]/					
RE SOLVE	FRESHWATER	COMMUNITY	INVERT	COM DIV	FIELD SAMP	AWQC	BOTH
		INDIVIDUAL	FISH	TIS RES	FIELD SAMP	AWQC	BOTH
		NS	NS	CTM MED	MEDIA SAMP	AWQC	BOTH
	WETLAND	NS	NS	CTM MED	MEDIA SAMP	BKGD	BOTH

---

[a] Background = reference area nearby.

[b] No observed impacts reported in available documentation; however, documentation is incomplete.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
SULLIVAN'S LEDGE	TERRESTRIAL	COMMUNITY	PLANT, BIRD, MAMMAL, AMPHIB, REPT	COM DIV	QUAL SURV	N/A	ECO
	TERR-AQUATIC	COMMUNITY	PLANT, BIRD, MAMM, AMPHIB, REPT	COM DIV	QUAL SURV	N/A	ECO
	FRESHWATER	COMMUNITY	FISH, BENTHIC	COM DIV	QUAL SURV	N/A	ECO
	WETLAND	COMMUNITY	PLANT	COM DIV	QUAL SURV	N/A	ECO
CONFIDENTIAL #1	TERR-AQUATIC	--NOT SPECIFIED[a]----------------------------------					
	FRESHWATER	--NOT SPECIFIED[a]----------------------------------					
	WETLAND	--NOT SPECIFIED[a]----------------------------------					
CONFIDENTIAL #3	ESTUARINE	INDIVIDUAL	FISH, SHELL, INVERT	TIS RES	FIELD SAMP[b]	BKGD	BOTH
		NS	NS	CTM MED	FIELD SAMP[b]	BKGD	BOTH
CONFIDENTIAL #6	FRESHWATER	NS	NS	CTM MED	MEDIA SAMP	AWQC-AC,CC, AL,CL,NSF, MORT 50-NSF	BOTH

---

[a] No observed impacts reported in available documents; documentation incomplete.

[b] Available documentation focused mainly on evaluating potential impacts; existing impacts described in introductory sections included contaminated biota, sediments, and water.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
EPA REGION 2							
CHEMICAL CONTROL	ESTUARINE	COMMUNITY	INVERT	COM DIV, IND SPE,	FIELD SAMP[a]	NS	ECO
		INDIVIDUAL	INVERT	TIS RES	FIELD SAMP[a]		
		NS	NS	CTM MED	MEDIA SAMP[a]	AWQC	
CLOTHIER SITE	TERRESTRIAL	INDIVIDUAL	MAMMAL, PLANT	TIS RES	FIELD SAMP	BKGD	ECO
	FRESHWATER	INDIVIDUAL	FISH	TIS RES, DIS/ABN	FIELD SAMP	BKGD	ECO
			PLANT	TIS RES	FIELD SAMP	BKGD	ECO
	WETLAND	COMMUNITY	PLANT	COM DIV	QUAL SURV	BKGD	ECO
		INDIVIDUAL	PLANT, FISH	DIS/ABN	QUAL SURV	BKGD	ECO
HUDSON RIVER	TERRESTRIAL	INDIVIDUAL	PLANT	TIS RES	FIELD SAMP	BKGD	BOTH
		NS	NS	CTM MED	MEDIA SAMP	BKGD	BOTH
	FRESHWATER	INDIVIDUAL	FISH	TIS RES	FIELD SAMP	FDA	HUM
			INVERT-MACRO	TIS RES	FIELD SAMP	BKGD	HUM
			INVERT-OTHER[b]	TIS RES	FIELD SAMP	BKGD	HUM
			INVERT-SHELL	TIS RES	BIOASS/IN SITU	BKGD	HUM
		NS	NS	CTM MED	MEDIA SAMP	AWQC	HUM

---

[a] Sampling not conducted for site - data from Army Corps of Engineers and U.S. Fish and Wildlife Service sampling at nearby sites.

[b] Zooplankton, blue crabs, and freshwater clams.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
LIPARI LANDFILL	FRESHWATER	COMMUNITY	FISH, OTHER[a]	COM DIV	FIELD SAMP	NS	ECO
				TIS RES	FIELD SAMP	FDA	HUM
		NS	NS	CTM MED	MEDIA SAMP	AWQC,AC,CC; LOC STD	BOTH
	WETLAND	INDIVIDUAL	PLANT	MORT	FIELD SAMP	N/A	ECO
		NS	NS	CTM MED	MEDIA SAMP	BKGD[b]	
MARATHON BATTERY[c]	TERR-AQUATIC	INDIVIDUAL	MAMMAL	TIS RES	FIELD SAMP	BKGD	ECO
			NS	DIS/ABN	FIELD SAMP	BKGD	ECO
	FRESHWATER	INDIVIDUAL	FISH	TIS RES	FIELD SAMP	BKGD	ECO
			NS	CTM MED	MEDIA SAMP	AWQC-CC,AC, NSF, LOC STD	ECO
	WETLAND	COMMUNITY	PLANT	VEG STR	OTHER[d]	NS	ECO
			OTHER[e]	COM DIV	FIELD SAMP	NS	ECO
		INDIVIDUAL	PLANT	TIS RES	FIELD SAMP	BKGD	ECO
			OTHER[f]	TIS RES	FIELD SAMP	BKGD	ECO
			REPT	TIS RES, DIS/ABN	FIELD SAMP	BKGD	ECO
			MAMMAL	TIS RES, REPROD	FIELD SAMP	BKGD	ECO

---

[a] Phytoplankton.

[b] Benchmark is background because no standards or guidelines exist for soils/sediments.

[c] Available documentation was not complete.

[d] Infrared photograph.

[e] Benthic algae.

[f] Phytoplankton, Zooplankton.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

Site	Ecosystem(s) of Concern	RECEPTOR CHARACTERIZATION Level of Organization	Taxonomic Group	Type(s) of End Point(s)	IMPACTS CHARACTERIZATION Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
EPA REGION 3							
ARMY CREEK LANDFILL	FRESHWATER	COMMUNITY	FISH	COM DIV	FIELD SAMP	NS	ECO
			INVERT	COM DIV, IND SPE	FIELD SAMP		
		INDIVIDUAL	FISH	DIS/ABN, TIS RES	FIELD SAMP		
		NS	NS	CTM MED	MEDIA SAMP		
CHISMAN CREEK	FRESHWATER	INDIVIDUAL	PLANT, FISH	TIS RES	FIELD SAMP	BKGD[a]/	ECO[b]/
			FISH	DIS/ABN	OTHER[c]/	BKGD[d]/	
	ESTUARINE	INDIVIDUAL	OYSTERS	TIS RES DIS/ABN	FIELD SAMP OTHER[f]/	BKGD[e]/ NS	ECO
		COMMUNITY	MACRO-BENTHIC	COM DIV	FIELD SAMP	BKGD[g]/	ECO

---

[a] Background values for fish as reported in the USFWS National Contaminant Biomonitoring Program and in the original literature.

[b] Whole in residue levels used.

[c] Histopathogical examination.

[d] BKGD = reference area nearby.

[e] Background values from a reference area and in the original literature.

[f] Histological examination.

[g] BKGD = reference area nearby.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
DELAWARE SAND AND GRAVEL	FRESHWATER	COMMUNITY	FISH	COM DIV	FIELD SAMP	NS	ECO
			INVERT	COM DIV, IND SPE	FIELD SAMP		
		INDIVIDUAL	FISH	DIS/ABN, TIS RES	FIELD SAMP		
		NS	NS	CTM MED	MEDIA SAMP		
DOUGLASVILLE	FRESHWATER	INDIVIDUAL	FISH	TIS RES	OTHER[a]	BKGD	BOTH
		NS	NS	CTM MED	MEDIA SAMP	OTHER[a]	BOTH
LA CLARKE	FRESHWATER	COMMUNITY	INVERT-BENTHIC	COM DIV	FIELD SAMP	REFERENCE AREA[b]	ECO
		INDIVIDUAL	FISH	DIS/ABN	OTHER[c]	REFERENCE AREA[d]	ECO
	WETLAND	NS	NS	NS	NS[e]	NS	ECO
NEW CASTLE STEEL	FRESHWATER	NS	NS	CTM MED	MEDIA SAMP	AWQC-CC,AC	BOTH
	WETLAND	NS	NS	CTM MED	MEDIA SAMP	AWQC-CC,AC	BOTH

---

[a] Data from STORET and other monitoring programs.

[b] Sampling points included an upstream reference area, an area of potential maximum impact, and an area of downstream impact.

[c] Gross necropsy, histopathology.

[d] Sampling points were an upstream reference area and an area of downstream impact.

[e] As part of the RI, the USFWS conducted a wetland assessment. Results were presented in documents not available at the time of review.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
PALMERTON ZINC	TERRESTRIAL	ECOSYSTEM	N/A	OTHER[a]/	FIELD SAMP	NONE	ECO
		COMMUNITY	PLANT, VERT, INVERT	VEG ABS, COM DIV	FIELD SAMP	NONE	ECO
	FRESHWATER	INDIVIDUAL	FISH	TIS RES	FIELD SAMP	BKGD	ECO
TYBOUTS CORNER	WETLAND	COMMUNITY	PLANT	VEG STR	QUAL SURV	N/A	ECO
			NS	COM DIV			
TYSON'S DUMP	TERRESTRIAL	COMMUNITY	PLANT	VEG STR	OTHER[b]/	N/A	ECO
	FRESHWATER	COMMUNITY	FISH, MACRO	COM DIV	QUAL SURV	N/A	ECO
	WETLAND	COMMUNITY	PLANT	VEG STR	OTHER[b]/	N/A	ECO
			VERT, MACRO	COM DIV	QUAL SURV	N/A	ECO
WEST VA ORDINANCE	TERRESTRIAL	COMMUNITY	PLANT	VEG ABS	FIELD SURV	N/A	ECO
			BIRD, MAMM	COM DIV	QUAL EVAL	N/A	ECO
	FRESHWATER	COMMUNITY	FISH	COM DIV	QUAL EVAL	N/A	ECO
	WETLAND	COMMUNITY	FISH, MAMM, BIRD	COM DIV	QUAL EVAL	N/A	ECO

---

[a] 2000 acres of deciduous woodland completely defoliated. Numerous surveys document the absence of soil microflora; depressed lichen communities; reduced arthropod density; absence of earthworms, slugs, snails, toads, and salamanders; and elevated metal tissue residue levels in fish.

[b] Aerial infrared photography used to determine whether vegetation on site and in wetlands is stressed.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
WILDCAT LANDFILL	TERRESTRIAL	COMMUNITY	PLANT, INVERT, VERT	COM DIV	QUAL SURV	N/A	ECO
		INDIVIDUAL	MAMM	DIS/ABN	OTHER[a]	BKGD[b]	ECO
	FRESHWATER	COMMUNITY	FISH, INVERT-BENTHIC	COM DIV	FIELD SAMP	BKGD[b]	ECO
		INDIVIDUAL	FISH	DIS/ABN	OTHER[a]	BKGD[b]	ECO
	ESTUARINE	COMMUNITY	PLANT, INVERT, VERT	COM DIV	QUAL SURV	N/A	ECO
	WETLAND	COMMUNITY	PLANT, INVERT, VERT	COM DIV	QUAL SURV[c]	N/A	ECO
WINCHESTER TIRE FIRE SITE	FRESHWATER	COMMUNITY	MACRO-BENTHIC	COM DIV	FIELD SAMP	REFERENCE AREA	ECO

---

[a] Histopathological examination of specimens sampled from field.

[b] BKGD = nearby reference areas and similar habitat in Maryland.

[c] Aerial photography used to document permanent loss of 29.1 acres of tidal wetland and permanent alteration of 7.9 acres of tidal wetland to upland palustrine (isolated) wetland.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
EPA REGION 4							
AMERICAN CREOSOTE WORKS, INC.	TERRESTRIAL	NS	NS	CTM MED	MEDIA SAMP	DETECT	BOTH
	MARINE	NS	NS	CTM MED	MEDIA SAMP	DETECT	BOTH
58th STREET LANDFILL	WETLAND	NS	NS	QUAL SURV	NONE	ECO	
GEIGER SITE	TERRESTRIAL	COMMUNITY	PLANT	VEG ABS	QUAL SURV	N/A	ECO
	FRESHWATER	NS	NS	CTM MED	MEDIA SAMP	AWQC-CC	ECO
	WETLAND	POPULATION	PLANT	MORT	MEDIA SAMP	OTHER[a]/	ECO
HARRIS CORPORATION	ESTUARINE	-----------------------------------NOT EVALUATED-----------------------------------					
MOWBRAY ENGINEERING	FRESHWATER	COMMUNITY	PLANT, FISH, INVERT	COM DIV	FIELD SAMP	N/A	ECO
		POPULATION	FISH	MORT	OTHER[b]/	N/A	N/A
		INDIVIDUAL	FISH	TIS RES	FIELD SAMP	FDA	HUM
	WETLAND	COMMUNITY	PLANT	VEG STR	OTHER[c]/	N/A	ECO
		INDIVIDUAL	PLANT	TIS RES	FIELD SAMP	BKGD	ECO

---

[a] Original literature concentration of lead (100-400 ppm in soil) considered toxic to agricultural plants.

[b] Historical records of fish kills.

[c] Aerial photography.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
MUNISPORT LANDFILL	TERRESTRIAL	NOT EVALUATED					
	FRESHWATER	INDIVIDUAL	FISH	TIS RES	FIELD SAMP	BKGD	BOTH
	WETLAND	INDIVIDUAL	FISH	TIS RES	FIELD SAMP	BKGS	BOTH
NEWPORT DUMP SITE	TERRESTRIAL	NOT EVALUATED					
	FRESHWATER	INDIVIDUAL	FISH	TIS RES, DIS/ABN	FIELD SAMP	BKGD	HUM
		COMMUNITY	INVERT-BENTHIC	COM DIV	QUAL SURV	NS	ECO
PARRAMORE SURPLUS	TERRESTRIAL	COMMUNITY	PLANT	VEG ABS	QUAL SURV	N/A	ECO
SAPP BATTERY	FRESHWATER	ECOSYSTEM	FISH, MACRO, OTHER[b]	COM DIV[a]	FIELD SAMP	N/A	ECO
		INDIVIDUAL	FISH, SHELL	TIS RES	FIELD SAMP	NS	HUM
	WETLAND	COMMUNITY	PLANT	VEG ABS	QUAL SURV	N/A	ECO
62nd STREET SITE	FRESHWATER	POPULATION	FISH	MORT	OTHER[c]	N/A	N/A
	WETLAND	NOT EVALUATED					
STAUFFER CHEMICAL	WETLAND	COMMUNITY	PLANT	VEG STR	QUAL SURV	N/A	ECO
		INDIVIDUAL	FISH	TIS RES	FIELD SAMP	BKGD	HUM

---

[a] Field sampling revealed a severely stressed ecosystem with altered community diversity of organisms living on, in, and near contaminated sediments.

[b] Algae, phytoplankton.

[c] The only evaluation of observed effects was a fish kill (in 1976) in the adjacent breeding ponds.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
EPA REGION 5							
EAU CLAIRE	TERRESTRIAL	NOT EVALUATED[a]					
	FRESHWATER	NOT EVALUATED[a]					
FORT WAYNE REDUCTION	TERRESTRIAL	COMMUNITY	PLANT, BIRD, MAMM	COM DIV	QUAL SURV	N/A	ECO
	FRESHWATER	COMMUNITY	FISH	COM DIV	QUAL SURV	N/A	ECO
	ESTUARINE	INDIVIDUAL	FISH	DIS/ABN	FIELD SAMP	NS	ECO
FULTZ LANDFILL	FRESHWATER	NS	NS	CTM MED	MEDIA SAMP	AWQC-AC, CC	BOTH
LIQUID DISPOSAL	FRESHWATER	COMMUNITY	MACRO-INVERT	COM DIV	FIELD SAMP	NS	BOTH
		INDIVIDUAL	FISH, OTHER[b]	TIS RES[a]	FIELD SAMP	FDA	HUM
		NS	NS	CTM MED	MEDIA SAMP	LOC STD, BKGD, AWQC, OTHER[c]	
	WETLAND	COMMUNITY	PLANT	VEG STR	FIELD SURV	N/A	ECO

---

[a] Problem is contaminated ground water; no impacts to biota are expected.

[a] Elevated tissue residue levels of PCBs and DDT metabolites; source concluded that leachate does not reach river; contamination in river from ground water.

[b] Crayfish.

[c] Great Lakes water quality criteria.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
MARION/BRAGG LANDFILL	TERRESTRIAL	POPULATION	PLANT	VEG STR	QUAL SURV	NONE	ECO
	FRESHWATER	NS	NS	CTM MED	MEDIA SAMP	AWQC	HUM
OUTBOARD MARINE	FRESHWATER	COMMUNITY	FISH, INVERT[a]	COM DIV	FIELD SAMP	N/A	ECO
		INDIVIDUAL	FISH, SHELL, BIRD, MACRO-BENTHIC	TIS RES	FIELD SAMP	NONE	ECO
SCHMALZ DUMP	FRESHWATER	NS	NS	CTM MED	MEDIA SAMP	AWQC-AC, CC, LOEL[b]	HUM
SEYMORE RECYCLING CORPORATION	TERRESTRIAL	INDIVIDUAL	BIRD, MAMM	MORT	OTHER[c]	N/A	N/A
			INVERT-MACRO	TIS RES	FIELD SAMP	BKGD	ECO
			MAMMAL	TIS RES	FIELD SAMP	BKGD	ECO
	FRESHWATER	POPULATION	FISH	MORT	OTHER[d]	N/A	N/A
		INDIVIDUAL	FISH, OTHER[e]	TIS RES	FIELD SAMP	BKGD	ECO
			REPT	TIS RES	FIELD SAMP	BKGD	ECO
VELSICOL SITE	FRESHWATER	--NOT EVALUATED--					

---

[a] Benthic macroinvertebrates, phytoplanakton, zooplankton.

[b] A chronic LOEL literature value for PAHs on fish.

[c] Reported sightings of dead individuals.

[d] Documented fish kills.

[e] Crayfish.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
EPA REGION 6							
MID-SOUTH WOOD PRODUCTS	TERRESTRIAL	COMMUNITY	PLANT	VEG ABS	FIELD SAMP	N/A	N/A
	FRESHWATER	POPULATION	FISH	MORT	OTHER[a]	N/A	N/A
UNITED NUCLEAR	TERRESTRIAL	INDIVIDUAL	MAMM[b]	TIS RES	FIELD SAMP	BKGD	HUM
	FRESHWATER	------NOT EVALUATED------					
WICHITA MOUNTAIN	TERRESTRIAL	------NOT EVALUATED------					
	FRESHWATER	INDIVIDUAL	FISH	TIS RES	FIELD SAMP	FDA	HUM
EPA REGION 8							
CONFIDENTIAL #2	TERRESTRIAL	------NOT SPECIFIED[c]------					
	FRESHWATER	------NOT SPECIFIED[c]------					
CONFIDENTIAL #4	TERRESTRIAL	INDIVIDUAL	MAMM	OTHER[d]	OTHER[e]	N/A	N/A
	FRESHWATER	COMMUNITY	FISH	COM DIV	FIELD SAMP	NS	ECO

---

[a] Historical record of fish kill.

[b] Livestock.

[c] No impacts specified, although available documentation was incomplete.

[d] Chemical burns noted on livestock straying into contaminated area.

[e] Historical records.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
EPA REGION 9							
IRON MOUNTAIN MINE	TERR-AQUATIC	----------------	----------------	------NOT EVALUATED	----------------	----------------	----------------
	FRESHWATER	POPULATION	FISH	MORT, GROWTH, MIGRATE	FIELD SAMP	AWQC, OTHER[a]	ECO
CONFIDENTIAL #5	TERRESTRIAL	COMMUNITY	PLANT	VEG ABS	QUAL SURV	NONE	ECO
	FRESHWATER	COMMUNITY	PLANT	VEG ABS	QUAL SURV	NONE	ECO
EPA REGION 10							
QUEEN CITY FARMS	TERRESTRIAL	COMMUNITY	PLANT	VEG STR	QUAL SURV	N/A	ECO
	FRESHWATER	----------------	----------------	----------------	NOT EVALUATED	----------------	----------------
	WETLAND	----------------	----------------	----------------	NOT EVALUATED	----------------	----------------

---

[a] Species-specific contaminant levels determined by the State of California's Department of Fish and Game.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
RCRA							
SACO DEFENSE, INC **RCRA #1**	TERRESTRIAL	----------	----------	----------	NOT EVALUATED	----------	----------
	FRESHWATER	----------	----------	----------	NOT EVALUATED	----------	----------
WYMAN-GORDON **RCRA #2**	FRESHWATER	COMMUNITY	PLANT	COM DIV	QUAL SURV	BKGD[a]/	ECO
	WETLAND	COMMUNITY	PLANT	COM DIV	FIELD SAMP	BKGD[a]/	ECO
		INDIVIDUAL	PLANT	VEG STR, REPROD, GROWTH	FIELD SAMP	BKGD[a]/	ECO
ALLIED CHEMICAL **RCRA #3**	ESTUARINE	COMMUNITY	INVERT-BENTHIC	COM DIV	FIELD SAMP	BKGD[b]/	ECO
		INDIVIDUAL	SHELL	TIS RES[c]/	FIELD SAMP	BKGD[d]/	HUM
DEFENSE GENERAL SUPPLY CENTER **RCRA #4**	FRESHWATER	COMMUNITY	INVERT-BENTHIC	COM DIV	FIELD SAMP	BKGD[e]/	ECO

---

[a] Nearby reference area.

[b] Background = reference area and other studies in Baltimore Harbor area.

[c] Only muscle tissue analyzed (focus on human health).

[d] Tissue residue levels correlated with environmental concentrations, compared with residue levels elsewhere in the northeast.

[e] Reference area downstream.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

Site	Ecosystem(s) of Concern	RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
		Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
ROHM & HAAS[a] RCRA #5	TERRESTRIAL	NOT EVALUATED					
	TERR-AQUATIC	NOT EVALUATED					
	FRESHWATER	NOT EVALUATED					
	WETLAND	NOT EVALUATED					
KENNEDY SPACE CENTER RCRA #6	TERRESTRIAL	NOT EVALUATED					
	WETLAND	NOT EVALUATED					
MONROE AUTO RCRA #7	FRESHWATER	NS	NS	NS	QUAL SURV	NS	NS
PRATT AND WHITNEY RCRA #8	TERRESTRIAL	NOT EVALUATED					
	TERR-AQUATIC	NOT EVALUATED					
	FRESHWATER	NOT EVALUATED					
SOUTHERN DYE CO. RCRA #9	FRESHWATER	INDIVIDUAL	FISH	TIS RES	FIELD SAMP	BKGD	HUM
SOUTHERN WOOD PIEDMONT RCRA #10	WETLAND	NOT EVALUATED					
UNION CARBIDE AGRICULTURAL PRODUCTS COMPANY, INC RCRA #11	TERRESTRIAL	NOT EVALUATED					
	ESTUARINE	POPULATION	SHELL	MORT	FIELD SURV	BKGD[b]	ECO

---

[a] Documentation for site incomplete.

[b] Reference areas within estuary.

APPENDIX C (continued)

METHODS USED TO CHARACTERIZE ACTUAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			IMPACTS CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Type(s) of Method(s) Employed	Derivation of Benchmark	Selection of Sampling Point(s)
KOPPERS COMPANY, INC RCRA #12	TERRESTRIAL	COMMUNITY	PLANT	VEG ABS	QUAL SURV	N/A	NS
	FRESHWATER	NOT EVALUATED					
INTERNATIONAL PAPER CO., TREATED WOOD PRODUCTS PLANT RCRA #13	FRESHWATER	NOT EVALUATED					
NATIONAL INDUSTRIAL ENVIRONMENTAL SERVICES RCRA #14	TERRESTRIAL	INDIVIDUAL	BIRD	TIS RES	FIELD SAMP	BKGD	ECO
	FRESHWATER	COMMUNITY	INVERT, FISH	COM DIV	FIELD SAMP	BKGD[a]	ECO
		INDIVIDUAL	FISH	TIS RES, DIS/ABN	FIELD SAMP, OTHER[b]	BKGD	BOTH
IRECO CHEMICALS RCRA #15	TERRESTRIAL	POPULATION	BIRD	REPROD, BEHAVIOR	FIELD STUDIES	N/A	ECO
ARCO PRUDHOE BAY UNIT EASTERN OPERATING AREA RCRA #16	TERRESTRIAL	NOT EVALUATED					
	FRESHWATER	NOT EVALUATED					
	WETLAND	NOT EVALUATED					

---

[a] Background = typical communities for this type of stream in South Central Kansas.

[b] Pathological examination for internal and external evidence of tumors, lesions, morphological abnormalities, disease, parasites, and toxic or pollutant related stress.

APPENDIX D

SITE-BY-SITE LISTING OF METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS

APPENDIX D

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
O'CONNOR	TERRESTRIAL	POPULATION	BIRD, MAMMAL	REPROD	ECO	NONE	LOEL, BAF[a]
	TERR-AQUATIC	POPULATION	BIRD, REPTILE, MAMMAL	REPROD	ECO	NONE	LOEL, BCF[a]
	FRESHWATER	COMMUNITY, POPULATION	MICRO, MICRO, MACRO	COM DIV, POP DENSITY, GROWTH, REPROD	ECO	NONE	LOEL
			FISH	MORT			
		NS	NS	CTM MED	ECO	NONE	AWQC-CC
	WETLAND	COMMUNITY, POPULATION	MICRO, MACRO	COM DIV, POP DENSITY, GROWTH, REPROD	ECO	NONE	LOEL
			MAMMAL	REPROD			
		NS	NS	CTM MED	ECO	NONE	AWQC-CC

---

[a] Estimated dietary intake and composition in predator and bioaccumulation factor (or measured tissue residue levels) in prey used to determine site-specific contaminant levels in soils or sediments that would lead to exceedance of dietary LOEL in predator.

O'CONNOR (continued)

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	ECO	CONT/DERM, INGEST, FOOD CHAIN	OTHER[b/]	MODEL	QUOT-SING,[c/] QUAL EVAL	QUAL EVAL	QUAL EVAL	ADEQUATE
TERR-AQUATIC	ECO	FOOD CHAIN	OTHER[d/]	MODEL	QUOT-SING	QUAL EVAL	QUAL EVAL	ADEQUATE
FRESHWATER	ECO	SED-CONTACT, SED-INGEST, WAT COLUMN	N/A	MODEL[e/]	QUOT-SING, QUAL EVAL	QUAL EVAL	QUAL EVAL	ADEQUATE
	NS	WAT COLUMN	N/A	MEAS	QUOT-SING	QUAL EVAL	QUAL EVAL	INADEQUATE
WETLAND	ECO	SED-CONTACT, SED-INGEST,	N/A	MODEL[e/]	QUAL-EVAL, QUOT SING[f/]	QUAL EVAL	QUAL EVAL	ADEQUATE
	NS	WAT COLUMN	N/A	MEAS	QUOT-SING	QUAL EVAL	QUAL EVAL	INADEQUATE

---

[b] Birds assumed to eat 20% of weight daily; small mammals assumed to eat 200-300% of weight daily. Risks calculated for birds eating 25%, 50%, 75% and 100% terrestrial arthropods and earthworms. Small mammals assumed to eat 35% earthworms and 65% arthropods.

[c] Quotient method used for primary carnivores; risks to secondary carnivores evaluated qualitatively.

[d] Tissue residue in bethic macroinvertebrates estimated from sediment concentrations of contaminants and bioconcentration factors.

[e] Concentrations in water column estimated from concentration in sediment.

[f] Risks to mammals via direct contact and/or ingestion of contaminated water and sediments only could be estimated qualitatively.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
OLD SPRINGFIELD LANDFILL	TERRESTRIAL	POPULATION	MAMMAL, BIRD, INVERT	REPROD	ECO	NONE	LOEL, BAF[a]
	TERR-AQUATIC	-----NOT EVALUATED-----					
	FRESHWATER	POPULATION	FISH, INVERT-BENTHIC	REPROD, MORT	ECO	NONE	AWQC-CC, MORT-50-SF[b] BKGD,[c] BCF

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	NS	CONT/DERM, INGEST, FOOD CHAIN	OTHER[d]	MODEL	QUOT-SING, QUAL EVAL[e]	N/A	N/A	ADEQUATE
TERR-AQUATIC	-----NOT EVALUATED-----							
FRESHWATER	NS	WAT COLUMN	N/A	MEAS, MODEL[f]	QUOT-SING	NONE	NONE	ADEQUATE

---

[a] Estimated dietary intake, dietary habits, and bioaccumulation factors in prey used to derive site-specific soil criteria for birds.

[b] Safety Factor of 100 applied to LC_{50}

[c] BKGD = background tissue residue levels in fish in N.E. US.

[d] Birds assumed to eat 20% of weight daily; home range size of receptors used as a qualitative estimate by relative likelihood of exposure.

[e] Potential for adverse effects in mammals evaluated qualitatively.

[f] Tissue residue levels in fish and benthic invertebrates estimated from BCFs.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
RE SOLVE	TERR-AQUATIC	POPULATION	MAMMALS	OTHER[a]	BOTH	NONE	FDA, BIOACCUM
	FRESHWATER	NS	NS	CTM MED	BOTH	NONE	AWQC-CC

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	BOTH	FOOD CHAIN	FDA	MEAS, MODEL	QUOT-SING	NONE	AREAL EXTENT	ADEQUATE
FRESHWATER	BOTH	WAT COLUMN, FOOD CHAIN	OTHER[b]	MODEL	QUOT-SING	NONE	AREAL EXTENT	ADEQUATE

---

[a] Human health endpoints used as surrogates for wildlife.

[b] Numerous parameters in WASTOX model required intake/dose assumptions>

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
SULLIVAN'S LEDGE	TERRESTRIAL	NS	PLANT, BIRD, MAMMAL, AMPHIB, REPT	NS	BOTH	NONE	NONE
	TERR-AQUATIC	NS	PLANT, BIRD, MAMMAL, AMPHIB, REPT	NS	BOTH	NONE	NONE
	FRESHWATER	NS	FISH, INVERT	CTM MED	BOTH	NONE	AWQC-AC,CC, NSF
	WETLAND	NS	PLANT	CTM MED, NS	BOTH	NONE	AWQC-AC,CC,[a] NSF; NONE

---

[a] For aquatic species; no benchmark for terrestrial species.

SULLIVAN'S LEDGE (CONTINUED)

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	BOTH	CONT/DERM, INHAL, FOOD CHAIN	QUAL EVAL[b]	MEAS	QUAL EVAL	NONE	NONE	INADEQUATE
TERR-AQUATIC	BOTH	INGEST, INHAL, FOOD CHAIN	QUAL EVAL[b]	MEAS	QUAL EVAL	NONE	NONE	INADEQUATE
FRESHWATER	BOTH	WAT COLUMN, SED-INGEST, SED-CONTACT, FOOD CHAIN	N/A	MEAS	QUOT-SING	NONE	NONE	INADEQUATE
WETLAND	BOTH	FOOD CHAIN, WAT COLUMN, SED-INGEST, SED-CONTACT, INGEST, INHAL	N/A, QUAL EVAL[b]	MEAS	QUOT-SING,[c] QUAL EVAL	NONE	NONE	INADEQUATE

---

[b] Home range size and habitat requirements used qualitatively to estimate potential for exposure.

[c] Quotient used for aquatic species; qualitative evaluation for terrestrial species and plants.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
CONFIDENTIAL #1	TERR-AQUATIC	POPULATION	BIRD, MAMMAL	NS[a]	HUM	NONE	LOEL, NOEL, MORT-50-SF[b]
	FRESHWATER	NS	NS	NS	HUM	NONE	AWQC-CC
	WETLAND	POPULATION	PLANT,	MORT	HUM	NONE	MORT-50
			BIRD,	NS[a]	HUM	NONE	LOEL, NOEL
			MAMMAL	NS	HUM	NONE	MORT-50-SF[b]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	HUM	FOOD CHAIN,[c] INGEST	OTHER[d]	MODEL[e]	QUOT-SING	N/A	N/A	ADEQUATE
FRESHWATER	HUM	WAT COLUMN	N/A	MEAS	QUOT-SING	NONE	NONE	ADEQUATE
WETLAND	HUM	CONT/DERM,	N/A	MEAS	QUOT-SING	NONE	NONE	ADEQUATE
	HUM	WAT COLUMN, FOOD CHAIN	OTHER[d]	MODEL[e]	QUOT-SING	N/A	N/A	ADEQUATE

---

[a] Numerous endpoints listed in hazard section, but none specifically noted in risk assessment.

[b] Safety factor of 5 applied to LC_{50} to protect against acute hazards.

[c] Food chain evaluated for birds, direct ingestion of water evaluated for mammals.

[d] Ducks assumed to consume 10% of their weight daily, 20% of which is aquatic invertebrates. Mammals assumed to drink 1% of body weight daily.

[e] Concentrations of contaminants in aquatic invertebrates calculated from literature BCFs measured in short-term bioconcentration studies.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity - Measure(s)	Derivation of Benchmark
CONFIDENTIAL #3	ESTUARINE	ECOSYSTEM	FISH	REPROD[a]	BOTH	N/A	AWQC-CC,AC, SF; LOEL-SF; MORT-50; OTHER[d]
		COMMUNITY, POPULATION	FISH,[b] CRUSTACEANS, MOLLUSCS, ANNELIDS, PLANKTON	COM DIV[c], MORT, GROWTH	BOTH	N/A	AWQC-CC,AC, SF; LOEL-SF; MORT-50; OTHER[d]
		POPULATION	FISH, AMPHIPODS	MORT, REPROD	BOTH	BIOASS-LAB, LAB ORGS	OTHER[e]

---

[a] Failure of adult fish to spawn assumed to be an indication of adverse impacts to ecosystem.

[b] Representative species selected to represent all trophic levels in the aquatic food web and both pelagic and benthic lifestyles.

[c] Endpoints based on most sensitive endpoint in taxonomic group evaluated (e.g., altered species diversity selected for algae, chronic mortality in invertebrates.

[d] NOEL concentration of PCBs in sediments.

[e] 0% effect level in bioassay.

CONFIDENTIAL #3 (CONTINUED)

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
ESTUARINE	BOTH	WAT COLUMN, SED-CONTACT, SED-INGEST, FOOD CHAIN	OTHER	MEAS, MODEL	OTHER[f]/	QUAL	QUAL	ADEQUATE
	BOTH	WAT COLUMN, SED-CONTACT, SED-INGEST, FOOD CHAIN	OTHER[g]/	MEAS,[h]/	QUOT-SING	QUANT[i]/,[j]/	QUANT[c]/	ADEQUATE
	BOTH	SED-CONTACT, SED-INGEST	N/A	N/A	BIOASSAY	NONE	NONE	ADEQUATE

---

[f] Qualitative fault-tree analysis of reproductive failure resulting from mortality, decreased population density, insufficient food, and a failure of eggs to form.

[g] Numerous assumptions required by Hydro Qual's Food Chain Model.

[h] Biomagnification through food chain modelled through use of Hydro Qual's Food Chain Model.

[i] Toxicity Quotient (TQ) method used to evalute relative severity of effects resulting from exposure to PCBs. TQ defined as Expected Environmental Concentration (EEL)/Benchmark. Scale of effects: TQ < 0.1 = no adverse effects; 0.1 < TQ < 10.0 = possible adverse effects; TO < 10.0 = probable adverse effects.

[j] Dietary intake exposure-response data from literature was used to derive a "scale" of adverse effects ranging from histological changes to reproductive failure in fish.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
CONFIDENTIAL SITE #6	TERR-AQUATIC	---NOT EVALUATED---					
	FRESHWATER	NS	NS	CTM MED	ECO	NONE	AWQC-AC,CC, AL,CL,NSF; MORT 50-NSF; LOEL[a]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	---NOT EVALUATED---							
FRESHWATER	BOTH	WAT COLUMN	N/A	MEAS	QUOT-SING	NONE	NONE	INADEQUATE

---

[a] LC_{50} for leopard frog from literature; chronic LOEL estimated by equation: In (chronic) = 0.78 (In LC_{50})$^{-1.87}$

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

Site	Ecosystem(s) of Concern	RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
		Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
CHEMICAL CONTROL	TERR-AQUATIC	NOT EVALUATED					
	ESTUARINE	N/S	N/S	CTM MED	HUM	NONE	AWQC-AC,NSF

Ecosystem(s) of Concern	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	NOT EVALUATED							
ESTUARINE	BOTH	WAT COLUMN	N/A	MEAS, MODEL	QUOT-SING	NONE	NONE	INADEQUATE

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
CLOTHIER SITE	TERRESTRIAL						
	FRESHWATER						
	WETLAND						

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL								
FRESHWATER								
WETLAND								

Note: Basically, because there is no evidence that contaminants have migrated off-site and no evidence of actual ecological impacts, an evaluation of potential impacts under the no-action alternative is unnecessary.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
HUDSON RIVER	TERRESTRIAL	NOT EVALUATED					
	TERR-AQUATIC	NOT EVALUATED					
	FRESHWATER	NOT EVALUATED					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	NOT EVALUATED							
TERR-AQUATIC	NOT EVALUATED							
FRESHWATER	NOT EVALUATED							

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
LIPARI LANDFILL	FRESHWATER	NOT SPECIFIED[a]					
	WETLAND	NOT SPECIFIED[a]					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	NOT SPECIFIED[a]							
WETLAND	NOT SPECIFIED[a]							

---

[a] Documents not available.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
MARATHON BATTERY	TERR-AQUATIC	INDIVIDUAL	MAMMAL	TIS RES, REPROD	ECO	N/A	NS
	FRESHWATER	INDIVIDUAL	INVERT	TIS RES	ECO	BIOASS/INSITU[a]	BKGD
		POPULATION	FISH	MORT	ECO	BIOASS/INSITU[b]	NS
		POPULATION	FISH, OTHER[c]	DIS/ABN, MORT, REPROD	ECO	N/A	MORT 50-AC, BCF
	WETLAND	---NOT EVALUATED---					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	ECO	FOOD CHAIN	NS	MEAS	QUOT-SING	NS	NS	NS
FRESHWATER	ECO	WAT COLUMN, SED-INGEST, SED-CONTACT	N/A	N/A	BIOASS	NONE	QUAL EVAL	NS
	ECO	WAT COLUMN	N/A	N/A	BIOASS	QUAL EVAL[d]	NS	NS
	ECO	WAT COLUMN	N/A	MODEL	QUOT-SING	NONE	NONE	ADEQUATE
WETLAND	---NOT EVALUATED---							

NOTE: Available documentation was not complete.

---

[a] Bioassay was a bioaccumulation study.

[b] Fish transplanted from a nearby area failed to survive. Conclusion was that genetic selection is occurring in contaminated area!

[c] Blue crabs and cladocerans.

[d] Concluded that genetic selection was occurring, but did not report how this conclusion was derived.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
ARMY CREEK LANDFILL	FRESHWATER	POPULATION	INVERT, FISH	MORT, REPROD	BOTH	BIOASS/LAB, LAB ORG	OTHER[a]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	ECO	WAT COLUMN	N/A	N/A	BIOASS	NONE	NONE	INADEQUATE

---

[a] 0% effect level in bioassay.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
CHISMAN CREEK	FRESHWATER	POPULATION	FISH, DAPANIA	MORT	ECO	BIOASS-LAB	OTHER[a]/
		NS	NS	CTM MED	ECO	N/A	AWQC-CC
	ESTUARINE	POPULATION	OTHER,[b]/ PLANT	MORT,[c]/ REPROD, OTHER[d]/	ECO	BIOASS-LAB	OTHER[a]/
		NS	NS	CTM MED	ECO	N/A	AWQC-CC

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	ECO	WAT COLUMN	N/A	N/A	BIOASS	BIOSS-QUANT	NONE	ADEQUATE
	ECO	NS	N/A	MEAS	QUOT-SING	OTHER[e]/	NONE	ADEQUATE
ESTUARINE	ECO	WAT COLUMN, SED-INGEST, SED-CONTACT	N/A	N/A	BIOASS	BIOASS-QUANT	NONE	ADEQUATE
	ECO	NS	N/A	MEAS	QUOT-SING	OTHER[e]/	NONE	ADEQUATE

---

[a] Not specified, but assumed to be 0% effect level in bioassay.

[b] Sea urchin, marine bacteria, marine microalgae, grass shrimp, blue mussel.

[c] Mortality of sea urchin sperm cells.

[d] Bioluminescence of marine bacteria.

[e] Criteria exceedances noted, but media bioassays need to determine nature of risks.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
DELAWARE SAND AND GRAVEL	FRESHWATER	POPULATION	INVERT, FISH	MORT, REPROD	BOTH	BIOASS/LAB, LAB ORG	OTHER[a]/

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	ECO	WAT COLUMN	N/A	N/A	BIOASS	NONE	NONE	INADEQUATE

---

[a] 0% effect level in bioassay.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
DOUGLASVILLE	FRESHWATER	NS	NS	CTM MED	HUM	NONE	BKGD

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	BOTH	NS	NS	MEAS	QUAL EVAL	NONE	NONE	INADEQUATE

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
LA CLARKE	FRESHWATER	POPULATION	DAPHNIA	MORT, REPROD	N/A	BIOASS-LAB[a]	REF AREA[b]
			FISH	MORT, GROWTH, OTHER[c]			
			BACTERIA	OTHER[d]			
			MOLLUSC	MORT, OTHER[c]			
		NS	FISH	OTHER[e]	ECO	N/A	LOC STD, LOEL, NSF

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	ECO	N/A	N/A	N/A	BIOASS	QUAL EVAL	QUANT	ADEQUATE
	ECO	WAT COLUMN	N/A	MODEL	QUOT-SING	NONE	NONE	ADEQUATE

---

[a] Bioassays included those using water column (Ceriodaphnia, fish bacteria) and sediments (fish, molluscs).

[b] Samples used in the bioassays included an upstream reference area, an area of potential maximum impact, and an area of downstream impact.

[c] Respiration, osmoregulation.

[d] The MICROTOX assay uses bioluminescence as an indirect measure of mortality.

[e] "Sublethal deleterious effects" described in a document not available at the time of review.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
NEW CASTLE STEEL	FRESHWATER	NS	NS	CTM MED	BOTH	NONE	AWQC-AC,CC
	WETLAND	NS	NS	CTM MED	BOTH	NONE	AWQC-AC,CC

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	BOTH	WAT COLUMN	NONE	MEAS	QUOT-SING	NONE	NONE	ADEQUATE
WETLAND	BOTH	WAT COLUMN	NONE	MEAS	QUOT-SING	NONE	NONE	ADEQUATE

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
PALMERTON ZINC	TERRESTRIAL	NOT EVALUATED[a]					
	FRESHWATER	NOT EVALUATED[b]					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	NOT EVALUATED							
FRESHWATER	NOT EVALUATED							

---

[a] Observed impacts are very extensive and well characterized.

[b] Efforts have focused on one operable unit (the terrestrial ecosystem) to date.

APPENDIX D (continued)
METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
TYBOUTS CORNER LANDFILL	TERR-AQUATIC	---NOT EVALUATED---					
	WETLAND	POPULATION	FISH, DAPHNIA	MORT	N/A	BIOASS-LAB,	OTHER[a]
		NS	NS	NS	HUM	N/A	AWQC-CC,AL, SF[b]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterizatien of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	---NOT EVALUATED---							
WETLAND	HUM	WAT COLUMN	N/A	N/A	BIOASSAY	N/A	N/A	ADEQUATE
	HUM	NS	N/A	MEAS	QUOT-SING, QUAL EVAL[c]	NONE	NONE	INADEQUATE

---

[a] 0% effect level in bioassay.

[b] For substances with no chronic criteria, approximate acute-to-chronic ratio calculated from the lowest fraction for the parameter class of compound.

[c] Potential impacts from high BOD, COD discussed qualitatively.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
TYSONS DUMP	FRESHWATER	POPULATION	FISH	OTHER[a]	HUM	N/A	OTHER[b]
		NOT EVALUATED					
	WETLAND	POPULATION	FISH	OTHER[a]	HUM	N/A	OTHER[b]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	HUM	WAT COLUMN,	N/A	MODEL	QUOT-SING[c]	NONE	NONE	INADEQUATE
		FOOD CHAIN[d]	NOT EVALUATED					
WETLAND	HUM	WAT COLUMN	N/A	MODEL	QUOT-SING[c]	NONE	NONE	INADEQUATE

---

[a] Unspecified "chronic effects against fish".

[b] Geometric mean of the maximum allowable toxic concentration from LC_0 values in fish using method of Suter et al (1983).

[c] Assumed chronic fish criteria will also protect invertebrate and plant life.

[d] Potential impacts to aquatic organisms from ingesting contaminated biota not considered despite suggestive evidence for elevated tissue residue levels in fish and freshwater clams.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
WEST VA ORDINANCE	TERRESTRIAL	POPULATION	BIRD, MAMMAL	MORT, OTHER[a]	HUM	NONE	NONE
	TERR-AQUATIC	NOT EVALUATED					
	FRESHWATER	POPULATION	FISH	MORT, OTHER[a]	HUM	NONE	MORT-50,SF[b]
	WETLAND	NOT EVALUATED					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	HUM	CONT/DERM, FOOD CHAIN	N/A	N/A	QUAL EVAL	NONE	QUAL EVAL	INADEQUATE
TERR-AQUATIC	NOT EVALUATED							
FRESHWATER	HUM	WAT COLUMN[c],[d]	N/A	MEAS	QUOT-SING	NONE	NONE	INADEQUATE
WETLAND	NOT EVALUATED							

---

[a] Qualitative evaluation of the likelihood of acute mortality or "chronic effects".

[b] An acute-to-chronic safety factor of 100 was used.

[c] No evaluation of potential exposures via contact with or ingestion of known contaminated sediments.

[d] Criteria for the protection of human health (i.e., soil, sediment, and water column) included an estimate of tissue residue levels in fish, but no attempt was made to evaluate the potential for significant wildlife exposure via ingestion of these fish.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
WILDCAT LANDFILL	TERRESTRIAL	INDIVIDUAL	MAMMAL	TIS RES	ECO	N/A	OTHER[a]
	FRESHWATER	POPULATION	FISH, DAPHNIA, BACTERIA	MORT, GROWTH, REPROD	ECO	BIOASS-LAB[b]	OTHER[c]
		INDIVIDUAL	FISH, REPT	TIS RES	ECO	N/A	OTHER[a]
		NS	NS	CTM MED	ECO	N/A	AWQC-CC
	ESTUARINE	POPULATION	FISH, DAPHNIA, BACTERIA	MORT	ECO	BIOASS-LAB	OTHER[c]
	WETLAND	POPULATION	FISH, DAPHNIA, BACTERIA	MORT, GROWTH, REPROD	ECO	BIOASS-LAB[b]	OTHER[c]

---

[a] Values from literature used to determine whether observed tissue levels exceeded those known to cause adverse effects in the biota being sampled. Adverse effects included "stress", excess mortality, reduced growth and reproduction; abnormal development and behavior, and metabolic alterations.

[b] Bioassays performed on leachate and on sediment evaluate.

[c] Not specified, but assumed to be 0% effect level in bioassay.

WILDCAT LANDFILL (CONTINUED)

Ecosystem(s) of Concern	EXPOSURE CHARACTERIZATION Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	RISK ASSESSMENT Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	ECO	N/A	QUAL EVAL[d]	N/A	QUOT-SING	QUAL EVAL	NONE	ADEQUATE
FRESHWATER	ECO	N/A	N/A	N/A	BIOASS	QUAL EVAL	NONE	ADEQUATE
	ECO	N/A	QUAL EVAL[d]	N/A	QUOT-SING	QUAL EVAL	NONE	ADEQUATE
	ECO	N/A	N/A	MEAS	QUOT-SING	OTHER[e]	NONE	ADEQUATE
ESTUARINE	ECO	N/A	N/A	N/A	BIOASSAY	QUAL EVAL	NONE	ADEQUATE
WETLAND	ECO	N/A	N/A	N/A	BIOASSAY	N/A	N/A	ADEQUATE

---

[d] Tissue residue levels examined only in organisms known to be present on-site and whose home ranges were contained exclusively or largely within site (in other words, organisms most likely to be expressed to contaminants over most of their lifetime).

[e] Benchmark exceedances were linked to bioassay results by spatial association (water samples in which benchmark were exceeded were acutely toxic to freshwater life in bioassays).

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

Site	Ecosystem(s) of Concern	RECEPTOR CHARACTERIZATION Level of Organization	Taxonomic Group	Type(s) of End Point(s)	HAZARD CHARACTERIZATION Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
WINCHESTER TIRE FIRE SITE	FRESHWATER	POPULATION	FISH, DAPHNIA	NS[a]/	HUM	BIOASS-LAB, LAB ORG	NS[b]/
		NS	NS	CTM MED	HUM	N/A	AWQC-CC

Ecosystem(s) of Concern	EXPOSURE CHARACTERIZATION Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	RISK ASSESSMENT Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	HUM	N/A	N/A	N/A	BIOASS[c]/	NS	NS	NS
	HUM	N/A	N/A	MEAS	QUOT-SING[c]/	NS	NS	NS

---

[a] "Acute and chronic" toxic effects mentioned in available documentation; original documentation not available at time of review.

[b] Assumed to be 0% effect level in bioassay; not described in available documentation.

[c] Descriptions of Risk Assessments in available documentation inadequate.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
AMERICAN CREOSOTE WORKS, INC.	MARINE	NS	NS	CTM MED	HUM	NONE	AWQC-AL,CL, NSF
	TERRESTRIAL	NOT EVALUATED					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
MARINE	BOTH	WAT COLUMN, FOOD CHAIN	NONE	MEAS	QUOT-SING	NONE	NONE	INADEQUATE
TERRESTRIAL	NOT EVALUATED							

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
58th Street Landfill	WETLAND	-------NOT SPECIFIED-------		CTM MED	HUM	NONE	AWQC-AC,CC; OTHER[a]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
WETLAND	HUM	NS	N/A	MEAS	QUOT-SING	NONE	OMITTED	INADEQUATE

---

[a] Florida Water Quality Standards.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
GEIGER SITE	TERRESTRIAL	POPULATION	PLANT	MORT	ECO	NONE	OTHER[a]
		INDIVIDUAL	BIRD	NS	ECO	NONE	NS
	TERR-AQUATIC	INDIVIDUAL	BIRD, MAMM	NS	ECO	NONE	NS
	FRESHWATER	NS	FISH	CTM MED	ECO	NONE	AWQC-CC
	WETLAND	INDIVIDUAL	PLANT, REPT, AMPHIB	NS	ECO	NONE	NS

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	ECO	CONT/DERM	NS	MEAS	QUOT-SING	NONE	footnote[b]	ADEQUATE
	NS	FOOD CHAIN	NS	QUAL EVAL	QUAL EVAL[c]	N/A	footnote[d]	ADEQUATE
TERR-AQUATIC	NS	FOOD CHAIN, INGEST	NS	QUAL EVAL	QUAL EVAL[c]	N/A	footnote[d]	ADEQUATE
FRESHWATER	ECO	WAT COLUMN	NS	MEAS	QUOT-SING	NONE	QUAL EVAL	ADEQUATE
WETLAND	NS	WAT COLUMN	NS	QUAL EVAL	QUAL EVAL[c]	N/A	footnote[d]	ADEQUATE

---

[a] Soil concentrations considered toxic to plants.

[b] Noted small area devoid of vegetation.

[c] Qualitative Evaluation of Exposed Potential concluded that exposures would be minimal; therefore impacts would be limited>

[d] Small areal extent of contamination and lack of apparent migration of contaminants were factors affecting qualitative conclusions.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
HARRIS CORPORATION	ESTUARINE	POPULATION	NS	MORT	ECO	BIOASS/LAB	OTHER[a]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
ESTUARINE	ECO	WAT COLUMN	N/A	N/A	QUAL EVAL	NONE	NONE	NS

---

[a] 0% effect level in bioassay.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
MOWBRAY ENGINEERING	FRESHWATER	NS	NS	NS	BOTH	NONE	AWQC-CC
	WETLAND	NS	NS	NS	BOTH	NONE	NONE

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	BOTH	WAT COLUMN, SED-CONTACT, SED-INGEST	N/A	QUAL EST	QUAL EVAL[a]	NONE	NONE	ADEQUATE
WETLAND	BOTH	FOOD CHAIN, WAT COLUMN, SED-INGEST, SED-CONTACT, INGEST	N/A	MEAS	QUAL EVAL[a]	NONE	NONE	ADEQUATE

---

[a] Site-specific sampling was insufficient to conduct a risk assessment. The resulting assessment was highly qualitative.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
MUNISPORT	TERRESTRIAL	POPULATION	BIRD, MAMMAL	OTHER[a]	BOTH	N/A	NOEL, LOEL,[b] MORT-50-SF
	FRESHWATER	NS	NS	CTM MED	BOTH	N/A	AWQC-CC,AL; LOCSTDS
		POPULATION	FISH, DAPHNIA	MORT	N/A	BIOASS-LAB, LOCAL SPECIES	OTHER[c]
	ESTUARINE	NS	NS	CTM MED	BOTH	N/A	AWQC-CC,AL; LOCSTDS
		POPULATION	SEA URCHINS, MICROALGAE	MORT	N/A	BIOASS-LAB, LOCAL SPECIES	OTHER[c]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	BOTH	FOOD CHAIN,[d] INGESTION	OTHER[e]	MODEL	QUOT-SING	N/A	N/A	ADEQUATE
FRESHWATER	BOTH	WAT COLUMN	N/A	MEAS	QUOT-SING	NONE	EQUAL EVAL	ADEQUATE
	N/A	N/A	N/A	N/A	BIOASSAY	NONE	NONE	ADEQUATE
ESTUARINE	BOTH	WAT COLUMN	N/A	MEAS	QUOT-SING	NONE	QUAL EVAL	ADEQUATE
	N/A	N/A	N/A	N/A	BIOASSAY	NONE	NONE	ADEQUATE

---

[a] Numerous endpoints cited in hazard assessment, none specified in risk assessment.

[b] Safety factor of 1/5 applied to LC_{50}.

[c] 0% effect level in bioassay.

[d] Food chain evaluation for birds; direct ingestion of contaminated water evaluated for mammals.

[e] Intake assumption: birds assumed to take 50% of diet from site; mammals assumed to drink 17% of body weight daily.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

Site	Ecosystem(s) of Concern	RECEPTOR CHARACTERIZATION Level of Organization	Taxonomic Group	Type(s) of End Point(s)	HAZARD CHARACTERIZATION Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
NEWPORT DUMP SITE	TERRESTRIAL	POPULATION	BIRD, MAMMAL	NS	HUM	N/A	NONE
	FRESHWATER	POPULATION	FISH, DAPHNIA	MORT,[a]/ REPROD	N/A	BIOASS-LAB, LAB ORGS	OTHER[b]/
		NS	NS	CTM MED	HUM	N/A	AWQC-CC,AL; LOC STD

Ecosystem(s) of Concern	EXPOSURE CHARACTERIZATION Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	RISK ASSESSMENT Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	HUM	CONT/DERM, FOOD CHAIN, INGEST	NONE	QUAL EVAL	QUAL EVAL[c]/	NONE	NONE	INADEQUATE
FRESHWATER	ECO	WAT COLUMN	N/A	N/A	BIOASSAY	N/A	N/A	INADEQUATE
	HUM	NS	N/A	MEAS	QUOT-SING	N/A	N/A	INADEQUATE

---

[a] Only acute mortality evaluated.

[b] 0% effect level in bioassay.

[c] Highly qualitative evaluation threat exposures, and hence, impacts are unlikely.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
PARRAMORE SURPLUS	TERRESTRIAL	NS	NS	NS	HUM	NONE	NONE

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	HUM	NS	NONE	NS	QUAL EVAL	NONE	AREAL EXTENT	INADEQUATE,

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
SAPP BATTERY	FRESHWATER	NS	NS	NS	BOTH	NONE	LOC STD, AWQC-CC
	WETLAND	---NOT EVALUATED---					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	HUM	WAT COLUMN[a]	N/A	MODEL[b]	QUOT-SING	NONE	NONE	ADEQUATE
WETLAND	---NOT EVALUATED---							

---

[a] No food chain pathways evaluated despite evidence of contaminated fish and freshwater clam tissue residues.

[b] Concentrations in water column modelled from sediment concentrations.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
62nd STREET SITE	FRESHWATER	------NOT SPECIFIED------		CTM MED	HUM	NONE	AWQC-CC, LOC STD[a]
	WETLAND	-----NOT EVALUATED-----					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	HUM	WAT COLUMN	N/A	MEAS	QUOT-SING	NONE	NONE	NONE
WETLAND	-----NOT EVALUATED-----							

---

[a] Florida Department of Environmental Regulation standard to lead.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
STAUFFER CHEMICAL	WETLAND	NS	NS	CTM MED	HUM	NONE	AWQC-CC

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
WETLAND	HUM	WAT COLUMN[a/] SED-CONTACT, SED-INGEST, FOOD CHAIN	N/A	MEAS	QUOT-SING[b/],[c/]	NONE	NONE	INADEQUATE

---

[a] Pathways discussed only in a qualitative sense. No real impacts evaluation.

[b] Additional studies planned.

[c] Available documents incomplete.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
EAU CLAIRE	FRESHWATER	NS	NS	CTM MED	HUM	NONE	AWQC-CL,NSF; LOC STD, MORT-50-NSF

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	BOTH	WAT COLUMN	N/A	MODEL[a]/	QUOT-SING	N/A	N/A	ADEQUATE

---

[a] Concentrations in receiving waters estimated from ground water discharges.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
FORT WAYNE REDUCTION	TERRESTRIAL	NS	NS	NS	HUM	NONE	NONE
	FRESHWATER	POPULATION	FISH, MACRO, MICRO	MORT	HUM	NONE	MORT-50-SF[a]
		NS	NS	CTM MED	HUM	NONE	AWQC-CC

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	HUM	CONT/DERM, FOOD CHAIN, INGEST	NONE	QUAL EVAL	QUAL EVAL	NONE	NONE	ADEQUATE
FRESHWATER	ECO	WAT COLUMN[b]	NA	MEAS, MODEL[c]	QUOT-SING	NONE	NONE	ADEQUATE
	ECO	WAT COLUMN[b]	NA	MEAS, MODEL[c]	QUOT-SING	NONE	NONE	ADEQUATE

---

[a] Safety factor = 1/3 for acute effects; 1/20 for chronic effects applied to lowest identified LC_{50}.

[b] Exposures via food chain and sediments not evaluated despite known contamination of sediments and bioaccumulation of substances on site.

[c] Concentrations in leachate measured and modelled in receiving waters below mixing zone.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
FULTZ LANDFILL	TERR-AQUATIC	----------NOT EVALUATED----------					
	FRESHWATER	NS	NS	CTM MED	BOTH	NONE	BCF, AWQC-AC,CL

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	----------NOT EVALUATED----------							
FRESHWATER	BOTH	WAT COLUMN	NONE	MODEL	QUOT-SING	NONE	NONE	INADEQUATE

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
LIQUID DISPOSAL	TERR-AQUATIC	NOT EVALUATED					
	FRESHWATER	COMMUNITY	INVERT-BENTHIC	COM DIV	NS	N/A	NS
	WETLAND	COMMUNITY	"AQUATIC ORGANISMS"	NS	NS	N/A	N/A
		POPULATION	NS	MORT	NS	NONE	AWQC, OTHER[a/]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	NOT EVALUATED[b/]							
FRESHWATER	NS	WAT COLUMN SED-CONTACT	N/A	MEAS	QUAL EVAL	N/A	N/A	ADEQUATE
WETLAND	NS	WAT COLUMN, SED-CONTACT	N/A	QUAL EVAL	QUAL EVAL[c/]	N/A	NONE	INADEQUATE
	NS	WAT COLUMN, SED-CONTACT, SOIL-CONTACT	N/A	MEAS	QUOT-SING	N/A	N/A	ADEQUATE[d/]

---

[a] Unspecified "ecotoxicity test results".

[b] Potential impacts to terrestrial receptors in nature reserve (80 acres) not evaluated.

[c] Stressed vegetation noted; because vegetation is less sensitive to contamination than aquatic organisms, aquatic organisms probably also stressed.

[d] Exceedance of AWQC suggest that acute or chronic toxicity might occur, but there is no evidence of this at this time.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
MARION/BRAGG	TERRESTRIAL	POPULATION	MAMMALS	NS	HUM	NONE	NONE
	FRESHWATER	NS	NS	CTM MED	HUM	NONE	AWQC-AC,CC
	TERR-AQUAT	--NOT EVALUATED--					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	HUM	INGEST CONT/DERM	NONE	MEASURED	QUAL EVAL	NONE	NONE	INADEQUATE
FRESHWATER	HUM	WAT COLUMN	NONE	MEAS, MODEL	QUOT-SING	NONE	NONE	INADEQUATE
TERR-AQUAT	--NOT EVALUATED--							

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
OUTBOARD MARINE	TERR-AQUATIC	POPULATION	BIRD, MAMMAL	REPROD, MORT, DIS/ABN	BOTH	NONE	N/A
	FRESHWATER	ECOSYSTEM	N/A	OTHER[a]	BOTH	NONE	AWQC-CC
			PHYTO-PLANKTON	PHOTO-SYNTHESIS			
		POPULATION	FISH	GROWTH, REPROD, MORT	BOTH	NONE	AWQC-CC

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	ECO	FOOD CHAIN	N/A	N/A	QUAL EVAL	QUAL EVAL	QUAL EVAL	ADEQUATE
FRESHWATER	ECO	N/A	N/A	MEAS	QUOT-SING	QUAL EVAL	QUAL EVAL	ADEQUATE
		WAT COLUMN, FOOD CHAIN	N/A	MEAS	QUOT-SING	QUAL EVAL	QUAL EVAL	ADEQUATE

---

[a] Reduced elasticity of ecosystem, greater vulnerability to new sources of stress.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

Site	Ecosystem(s) of Concern	RECEPTOR CHARACTERIZATION: Level of Organization	RECEPTOR CHARACTERIZATION: Taxonomic Group	RECEPTOR CHARACTERIZATION: Type(s) of End Point(s)	HAZARD CHARACTERIZATION: Selection of Contaminant(s) of Concern	HAZARD CHARACTERIZATION: Site-Specific Toxicity Measure(s)	HAZARD CHARACTERIZATION: Derivation of Benchmark
SCHMALZ DUMP	FRESHWATER	COMMUNITY	INVERT	OTHER[a]	HUM	NONE	NONE
	WETLAND	NS	NS	NS	HUM	N/A	NS

Ecosystem(s) of Concern	EXPOSURE CHARACTERIZATION: Selection of Sampling Point(s)	EXPOSURE CHARACTERIZATION: Pathway(s) Considered	EXPOSURE CHARACTERIZATION: Intake/Dose Assumptions	EXPOSURE CHARACTERIZATION: Chemical Concentration at Receptor	RISK ASSESSMENT: Type(s) of Method Employed	RISK ASSESSMENT: Evaluation of Impacts Above Threshold	RISK ASSESSMENT: Characterization of Areal Extent/ Reversibility	RISK ASSESSMENT: Characterization of Uncertainty
FRESHWATER	HUM	SED-INGEST, SED-CONTACT, WAT COLUMN	NONE	MODEL	QUAL EVAL	NONE	NONE	INADEQUATE
WETLAND	HUM	N/S	N/A	QUAL EVAL	QUAL EVAL	NONE	NONE	INADEQUATE

---

[a] Unspecified "community effects".

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
SEYMORE RECYCLING CORPORATION	TERRESTRIAL	----------------NOT SPECIFIED---------------			HUM	NS	NS
	TERR-AQUATIC	----------------NOT SPECIFIED---------------			HUM	NS	NS
	FRESHWATER	NS	NS	CTM MED	HUM	NONE	AWQC-CL,AL; MORT 50; BCF

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	NS	CONT/DERM, FOOD CHAIN	NS	NS	QUAL EVAL	----------------------NONE-----------------------		
TERR-AQUATIC	NS	CONT/DERM, FOOD CHAIN	NS	NS	QUAL EVAL	----------------------NONE-----------------------		
FRESHWATER	HUM	WAT COLUMN	N/A	MODEL	QUOT-SING	N/A[a]	N/A[a]	ADEQUATE

NOTE: Endangered species occur near the site, but the site is not essential habitat. Exposure to these species is unlikely.

---

[a] No exceedances predicted.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
VELSICOL SITE	TERR-AQUATIC	NOT EVALUATED					
	FRESHWATER	NS	NS	NS	HUM[a]	NONE	AWQC-CC

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERR-AQUATIC	NOT EVALUATED							
FRESHWATER	HUM	WAT COLUMN, SED-CONTACT, SED-INGEST	N/A	MEAS	QUAL EVAL[b]	NONE	NONE	NONE

---

[a] Examined only pesticide contamination in fish (for potential effects on human health), although other organics and inorganics recognized as potential problems.

[b] Highly qualitative evaluation. There "is a potential for exposure through the surface water/sediment pathway." Potential exposures through food chain evaluated over the human health.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
MID-SOUTH WOOD PRODUCTS	TERRESTRIAL	NOT EVALUATED					
	FRESHWATER	NOT EVALUATED					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	NOT EVALUATED							
FRESHWATER	NOT EVALUATED							

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
UNITED NUCLEAR	TERRESTRIAL	NOT EVALUATED					
	FRESHWATER	NOT EVALUATED					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	NOT EVALUATED							
FRESHWATER	NOT EVALUATED							

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

<table>
<tr><th rowspan="2">Site</th><th rowspan="2">Ecosystem(s) of Concern</th><th colspan="3">RECEPTOR CHARACTERIZATION</th><th colspan="3">HAZARD CHARACTERIZATION</th></tr>
<tr><th>Level of Organization</th><th>Taxonomic Group</th><th>Type(s) of End Point(s)</th><th>Selection of Contaminant(s) of Concern</th><th>Site-Specific Toxicity Measure(s)</th><th>Derivation of Benchmark</th></tr>
<tr><td>WICHITA MOUNTAIN</td><td>TERRESTRIAL</td><td colspan="6">NOT EVALUATED</td></tr>
<tr><td></td><td>FRESHWATER</td><td colspan="6">NOT EVALUATED</td></tr>
</table>

<table>
<tr><th rowspan="2">Ecosystem(s) of Concern</th><th colspan="4">EXPOSURE CHARACTERIZATION</th><th colspan="4">RISK ASSESSMENT</th></tr>
<tr><th>Selection of Sampling Point(s)</th><th>Pathway(s) Considered</th><th>Intake/Dose Assumptions</th><th>Chemical Concentration at Receptor</th><th>Type(s) of Method Employed</th><th>Evaluation of Impacts Above Threshold</th><th>Characterization of Areal Extent/ Reversibility</th><th>Characterization of Uncertainty</th></tr>
<tr><td>TERRESTRIAL</td><td colspan="8">NOT EVALUATED</td></tr>
<tr><td>FRESHWATER</td><td colspan="8">NOT EVALUATED</td></tr>
</table>

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
CONFIDENTIAL #2	TERRESTRIAL	INDIVIDUAL	PLANT, MAMMAL	OTHER[a]/, MORT	HUM	NONE	LOC STD[b]/, MORT-50
	FRESHWATER	POPULATION	FISH, INVERT	MORT, OTHER[c]/	HUM	NONE	AWQC-CC, LOC STD, LOEL, MORT-50-SF[d]/

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	HUM	CONT/DERM INGEST	N/A	MEAS	QUOT-SING	N/A	QUAL EVAL	ADEQUATE
FRESHWATER	HUM	WAT COLUMN	N/A	MEAS	QUOT-SING	N/A	N/A	ADEQUATE

---

[a] Chronic, sublethal effects in humans (unspecified) from ingestion of contaminated crops and livestock.

[b] State standards for livestock and plants set to protect humans via consumption.

[c] Unspecified chronic effects.

[d] Safety factor of 1/100 applied to LC_{50} values.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
CONFIDENTIAL #4	TERRESTRIAL	POPULATION	BIRD	MORT	ECO	NONE	MORT-50[a]
			BIRD, PLANT, MAMMAL	OTHER[b] REPROD, MORT	ECO	NONE	NONE
	FRESHWATER	NS	NS	NS	ECO	NONE	AWQC-AC, CL, NSF
		POPULATION	FISH, AQUATIC, INVERT	OTHER[b]	ECO	NONE	NONE
	WETLAND	NS	NS	CTM MED	ECO	N/A	N/A

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	HUM	CONT/DERM	NONE	MEAS	QUOT-SING	N/A	N/A	ADEQUATE
	HUM	CONT/DERM, INGEST, FOOD CHAIN	NONE	QUAL EVAL	QUAL EVAL	NONE	NONE	ADEQUATE
FRESHWATER	HUM	WAT COLUMN	N/A	MEAS	QUOT-SING	NONE	NONE	ADEQUATE
	HUM	WAT COLUMN, SED-CONTACT, SED-INGEST FOOD CHAIN	N/A	QUAL EVAL	QUAL EVAL	NONE	NONE	ADEQUATE
WETLAND	N/A	N/A	N/A	N/A	QUAL EVAL[c]	N/A	N/A	ADEQUATE

---

[a] 8-day LC_{50} for mallards, bobwhite.

[b] Unspecified "chronic toxic effects".

[c] Potential contamination of nearby wetland noted.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
IRON MOUNTAIN MINE	FRESHWATER	POPULATION	FISH	MORT, GROWTH, MIGRATE	ECO	NONE	AWQC, OTHER[a]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	ECO	WAT COLUMN	N/A	MEAS	QUOT-SING	NONE	MEAS	NS

---

[a] Contaminant concentrations protective of salmon and steelhead developed by the California State Department of Fish and Game.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
CONFIDENTIAL SITE #5	TERRESTRIAL	POPULATION	BIRD, MAMM, REPTILE	NS	BOTH	NONE	NONE
	FRESHWATER	NS	NS	NS	BOTH	NONE	NONE

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	BOTH	INGEST, INHAL	NONE	MEAS	QUAL EVAL	NONE	AREAL EXTENT	ADEQUATE
FRESHWATER	BOTH	NS	NONE	NS	QUAL EVAL	NONE	AREAL EXTENT	INADEQUATE

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
QUEEN CITY FARMS	TERRESTRIAL	NS	NS	NS	HUM	NONE	AWQC-CC[a]
	TERR-AQUATIC	----------------	----------------	----------------	NOT EVALUATED	----------------	----------------
	FRESHWATER	NS	NS	CTM MED	HUM	NONE	AWQC-CC
	WETLAND	NS	NS	CTM MED	HUM	NONE	AWQC-CC[a]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	HUM	NS[b]	NONE	MEAS	QUAL EVAL	NONE	NONE	INADEQUATE
TERR-AQUATIC	----------------	----------------	----------------	----------------	NOT EVALUATED	----------------	----------------	----------------
FRESHWATER	HUM	WAT COLUMN[b]	N/A	MEAS	QUOT-SING	NONE	NONE	INADEQUATE
WETLAND	HUM	WAT COLUMN[b], [c]	N/A	MEAS	QUOT-SING	NONE	NONE	INADEQUATE

---

[a] AWQC-CC used as benchmarks for terrestrial organisms. This is clearly a misapplication.

[b] No evaluation of potential impacts due to food chain exposure although bioconcentrating chemicals found in soils and sediments.

[c] No evaluation of potential impacts due to contact/ingestion of contaminated sediments.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
SACO DEFENSE RCRA #1	FRESHWATER	NS	NS	NS	HUM	NONE	LOC STD[a]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	NS	WAT COLUMN	N/A	MEAS	QUOT-SING	NS	NS	NS

---

[a] Evaluation only in planning stage. AWQC not mentioned specifically, although "any other relevant criteria" are required.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
WYMAN-GORDON RCRA #2	FRESHWATER	NS	NS	CTM MED	ECO	NONE	AWQC-CC
	WETLAND	COMMUNITY	PLANT	COM DIV	ECO	NONE	BKGD

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	ECO	WAT COLUMN[a]	N/A	MODEL	QUOT-SING	N/A	N/A	ADEQUATE
WETLAND	ECO	WAT COLUMN	N/A	MEAS	QUAL-EVAL	N/A	QUAL-EVAL	INADEQUATE

---

[a] Effects due to ingestion of or contact with sediments not evaluated.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
ALLIED CHEMICAL BALTIMORE WORKS RCRA #3	ESTUARINE	INDIVIDUAL	CRABS	TIS RES	HUM	N/A	OTHER[a]
		NS	NS	CTM MED	ECO	N/A	AWQL-CL

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
ESTUARINE	ECO	WAT COLUMN	N/A	N/A	QUOT-SING	NONE	NONE	ADEQUATE
	ECO	WAT COLUMN	N/A	MEAS,[b] MODEL	QUOT-SING	NONE	QUANT EST[c]	INADEQUATE

---

[a] Tissue residue level, 4.0 mg total Cr/kg (dry weight), from literature associated with "adverse organismal or ecological effects".

[b] Near-field concentrations measured, far-field (long-term, steady state) concentrations modelled.

[c] State regulations require that the cross-sectional area of the mixing zone not exceed 10% of the cross-sectional area of the surface water body.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
DEFENSE GENERAL SUPPLY CENTER RCRA #4	FRESHWATER	NS	NS	NS	HUM	NONE	AWQC-CC
		POPULATION	FISH, DAPHNIA	MORT REPROD	ECO	BIOASS-LAB, LAB ORG	BKGD[a]/

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	HUM	WAT COLUMN	N/A	MEAS	QUOT-SING	NONE	NONE	NONE
	ECO	WAT COLUMN	N/A	N/A	BIOASS	NS[b]/	NS[b]/	NS[b]/

---

[a] Reference area downstream.

[b] Bioassays not conducted at the time of review.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
ROHM & HAAS[a] RCRA #5	TERRESTRIAL	NOT EVALUATED					
	TERR-AQUATIC	NOT EVALUATED					
	FRESHWATER	NOT EVALUATED					
	WETLAND	NOT EVALUATED					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	NOT EVALUATED							
TERR-AQUATIC	NOT EVALUATED							
FRESHWATER	NOT EVALUATED							
WETLAND	NOT EVALUATED							

---

[a] Documentation for site incomplete.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
KENNEDY SPACE CENTER RCRA #6	TERRESTRIAL	NOT EVALUATED					
	WETLAND	NOT EVALUATED					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above 'Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	NOT EVALUATED							
WETLAND	NOT EVALUATED							

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
MONROE AUTO EQUIPMENT RCRA #7	FRESHWATER	POPULATION	PLANT, FISH	CTM MED	HUM	NONE	AWQL-CL, NSF; MORT-50, NSF

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	HUM	WAT COLUMN	N/A	MEAS	QUOT-SING	N/A	N/A	ADEQUATE

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
PRATT AND WHITNEY RCRA #8	TERRESTRIAL	----------	----------	----------	NOT EVALUATED	----------	----------
	TERR-AQUATIC	----------	----------	----------	NOT EVALUATED	----------	----------
	FRESHWATER	----------	----------	----------	NOT EVALUATED	----------	----------

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	----------	----------	----------	----------	NOT EVALUATED	----------	----------	----------
TERR-AQUATIC	----------	----------	----------	----------	NOT EVALUATED	----------	----------	----------
FRESHWATER	----------	----------	----------	----------	NOT EVALUATED	----------	----------	----------

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
SOUTHERN DYE CO. **RCRA #9**	FRESHWATER	NS	NS	CTM MED	HUM	NONE	AWQC-CC, MORT-50-NSF

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	HUM	WAT COLUMN	N/A	MEAS	QUOT-SING[a]	NONE	NONE	INADEQUATE

---

[a] 52 hazardous constituents in contaminated ground water no attempt to use hazard index approach.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
SOUTHERN WOOD	WETLAND	POPULATION	FISH, ALGAE, DAPHNIA	MORT, REPROD	ECO	BIOASS-LAB, LAB ORG	BKGD[a]/

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
WETLAND	ECO	WAT COLUMN	N/A	N/A	BIOASSAY	NS	NS	NS

---

[a] Background = upgradient reference well.

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
UNION CARBIDE AGRICULTURAL PRODUCT COMPANY, INC RCRA #11	TERRESTRIAL	NS	MAMMAL, REPT	NS	BOTH	NONE	NONE
	ESTUARINE	NS	NS	CTM MED	BOTH	NONE	AWQC-CC, AL, NSF

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	BOTH	CONT/DERM INGEST	NONE	QUAL EVAL	QUAL EVAL	N/A	N/A	INADEQUATE
ESTUARINE	BOTH	WAT COLUMN	N/A	MODEL[a]/	QUOT-SING	NONE	NONE	INADEQUATE

---

[a] Modelled concentrations of contaminants in "acute zone" and "chronic zone" from discharge of ground water.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
KOPPERS COMPANY, INC. RCRA #12	TERRESTRIAL				NOT EVALUATED		
	FRESHWATER				NOT EVALUATED		

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL					NOT EVALUATED			
FRESHWATER					NOT EVALUATED			

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
INTERNATIONAL PAPER CO. TREATED WOOD PRODUCTS PLANT RCRA #13	FRESHWATER	NS	NS	CTM MED	HUM	NONE	AWQC-AL-CL, SF[a]; LOCSTD

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
FRESHWATER	HUM	WAT COLUMN	N/A	MODEL	QUOT-SING	NONE	NONE	NONE

---

[a] Safety factor of 1/100 used with AL, 1/10 used with CL. Dilution factor of 1/15 used for groundwater discharge to stream.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
NATIONAL INDUSTRIAL ENVIRONMENTAL SERVICES RCRA #14	TERRESTRIAL	NS	NS	NS	HUM	NONE	NONE
	FRESHWATER	NS	NS	CTM MED	NUM	NONE	AWQC-CC, MORT-50-SF[a]

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	N/A	N/A	N/A	QUAL EVAL	QUAL EVAL	N/A	QUAL EVAL	ADEQUATE
FRESHWATER	ECO	WAT COLUMN	N/A	MODEL	QUOT-SING[b]	N/A	N/A	INADEQUATE

---

[a] Chronic criterion (Geometric Mean maximum allowable toxicant concentration, GMATC) calculated from Suter (1983) as: ln GMATC = 0.78 in $LC_{50}^{-1.87}$, where LC_{50} is 96 hr. for fish.

[b] 35 constituents tested; 84 chemicals present at site (no toxicity data for remainder).

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
IRECO CHEMICALS RCRA #15	TERRESTRIAL	INDIVIDUAL	BIRD, MAMMAL	MORT, OTHER[a]/	N/A	N/A	N/A

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	ECO	N/A	N/A	N/A	QUAL EVAL	N/A	N/A	ADEQUATE

---

[a] Deafening from explosions.

APPENDIX D (continued)

METHODS USED TO CHARACTERIZE POTENTIAL ECOLOGICAL IMPACTS (continued)

		RECEPTOR CHARACTERIZATION			HAZARD CHARACTERIZATION		
Site	Ecosystem(s) of Concern	Level of Organization	Taxonomic Group	Type(s) of End Point(s)	Selection of Contaminant(s) of Concern	Site-Specific Toxicity Measure(s)	Derivation of Benchmark
ARCO PRUDHOE BAY UNIT-EASTERN OPERATING AREA[a]/ **RCRA #16**	TERRESTRIAL	NOT EVALUATED					
	FRESHWATER	NOT EVALUATED					
	WETLAND	NOT EVALUATED					

	EXPOSURE CHARACTERIZATION				RISK ASSESSMENT			
Ecosystem(s) of Concern	Selection of Sampling Point(s)	Pathway(s) Considered	Intake/Dose Assumptions	Chemical Concentration at Receptor	Type(s) of Method Employed	Evaluation of Impacts Above Threshold	Characterization of Areal Extent/ Reversibility	Characterization of Uncertainty
TERRESTRIAL	NOT EVALUATED							
FRESHWATER	NOT EVALUATED							
WETLAND	NOT EVALUATED							

---

[a] Qualitative screening evaluation only.

APPENDIX E

GLOSSARY OF ENTRIES IN APPENDICES

APPENDIX E

GLOSSARY OF ENTRIES USED IN APPENDICES

TERM	DEFINITION
AC	ACUTE CRITERION
AL	ACUTE LC_{50}
AMES	AMES TEST
AMPHIB	AMPHIBIAN
AWQC	AMBIENT WATER QUALITY CRITERIA
BCF	BIOCONCENTRATION FACTOR
BIOACCUM	BIOACCUMULATION FACTOR
BIOASS	MEDIA BIOASSAY
BIOASS/LAB	MEDIA BIOASSAY CONDUCTED IN LABORATORY
BIOASS/INSITU	MEDIA BIOASSAY CONDUCTED IN SITU
BIRD	BIRD
BKGD	BACKGROUND
BOTH	HUMAN HEALTH AND ECOLOGICAL
CC	CHRONIC CRITERIA
CL	CHRONIC LOEL
COM	COMMUNITY
COM DIV	COMMUNITY DIVERSITY/DIVERSITY INDEX
CONT/DERM	DIRECT CONTACT OR INGESTION DURING GROOMING OR PREENING
CTM MED	CONTAMINATED MEDIA
DETECT	DETECTION LIMIT
DIS/ABN	DISEASE, LESIONS, ABNORMALITIES, ETC.
ECO	ECOLOGICAL
EST	ESTIMATE
FDA	FDA ACTION LEVEL
FIELD SAMP	FIELD SAMPLE
FISH	FISH
FOOD CHAIN	UPTAKE THROUGH FOOD CHAIN
GROWTH	GROWTH AND DEVELOPMENT
HUM	HUMAN HEALTH
IND	INDIVIDUAL
IND SPE	PRESENCE/ABSENCE OF INDICATOR SPECIES
INGEST	DIRECT INGESTION
INHAL	INHALATION
INSITU	IN SITU
INVERT	INVERTEBRATE
LAB	LABORATORY
LAB ORG	LABORATORY ORGANISM
LOCSTD	STATE OR LOCAL STANDARD OR CRITERION
LOEL	LOWEST OBSERVED EFFECT LEVEL
MICRO	MICROINVERTEBRATE
MACRO	MACROINVERTEBRATE
MAMM	MAMMAL

APPENDIX E (continued)

GLOSSARY OF ENTRIES USED IN APPENDICES

TERM	DEFINITION
MEAS	SAMPLING/MEASUREMENT
MEDIA SAMP	MEDIA SAMPLE
MIGRATE	MIGRATION
MODEL	QUANTITATIVE MODELING
MORT	MORTALITY
MORT 50	LD_{50}, LC_{50}, EC_{50}
MULT	MULTIPLE CHEMICAL
N/A	NOT APPLICABLE
NE	NOT EVALUATED
NOEL	NO OBSERVED EFFECT LEVEL
NONE	NONE
NS	NOT SPECIFIED
NSF	NO SAFETY FACTOR USED
OMIT	OMITTED
OTHER(n)	OTHER (explanation below table in footnote n)
PLANT	PLANTS
POP	POPULATION
QUAL EST	QUALITATIVE ESTIMATE
QUAL EVAL	QUALITATIVE EVALUATION
QUAL SURV	QUALITATIVE SURVEY
QUANT	QUANTITATIVE
QUOT-SING	QUOTIENT METHOD, SINGLE CHEMICAL
REF AREA	REFERENCE AREA
REPROD	REPRODUCTION
REPT	REPTILE
SED-INGEST	INGESTION OF SEDIMENT
SED-CONTACT	DIRECT CONTACT WITH SEDIMENT
SF	SAFETY FACTOR USED
SHELL	SHELLFISH
SITE ORG	SITE-SPECIFIC ORGANISM
STD	STANDARD
TIS RES	TISSUE RESIDUE LEVELS
VEG ABS	ABSENCE OF VEGETATION
VEG STR	VEGETATIVE STRESS
VERT	VERTEBRATE
WAT COLUMN	WATER COLUMN